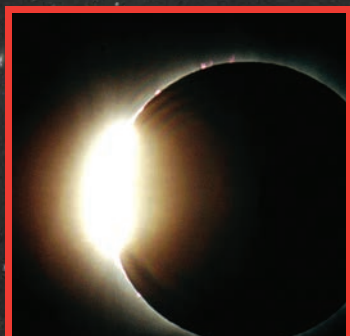


ASTRONOMY

2002

EASTERN
AUSTRALIAN
EDITION



Total Solar Eclipse in South
Australia this Year!

Suitable
for NSW, Vic,
Qld, SA, NT
& Tas.

A PRACTICAL GUIDE TO THE NIGHT SKY

Glenn Dawes

Peter Northfield

Ken Wallace

2002

January

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	●	7	8	9	10	11
13	●	14	15	16	17	18
20	21	22	●	23	24	25
27	28	29	○	30	31	

February

Sun	Mon	Tue	Wed	Thu	Fri	Sat
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17	18	19	20	●	21	22
24	25	26	27	○	28	

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31						

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28	29	30				○

May

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19	20	●	21	22	23	24
26	○	27	28	29	30	31

June

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
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9	10	11	●	12	13	14
16	17	18	●	19	20	21
23	24	25	○	26	27	28
30						

●
New Moon

●
First Quarter

July

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	●	4	5
7	8	9	10	●	11	12
14	15	16	17	●	18	19
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28	29	30	31			

August

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	●	2
4	5	6	7	8	9	●
11	12	13	14	15	●	16
18	19	20	21	22	23	○
25	26	27	28	29	30	31
						●

September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	●				

October

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	●	7	8	9	10	11
13	●	14	15	16	17	18
20	21	○	22	23	24	25
27	28	29	●	30	31	

November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4	5	●	6	7	8
10	11	12	●	13	14	15
17	18	19	20	○	21	22
24	25	26	27	28	●	29
						30

December

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	●	5	6
8	9	10	11	12	●	13
15	16	17	18	19	20	○
22	23	24	25	26	27	●
29	30	31				

○
Full Moon

●
Last Quarter

ASTRONOMY 2002

EASTERN AUSTRALIAN EDITION

A PRACTICAL GUIDE TO THE NIGHT SKY

**QUASAR
PUBLISHING
2001**

**GLENN DAWES
KEN WALLACE
PETER NORTHFIELD**

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Peter Northfield
Ken Wallace

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INTRODUCTION TO THE 2002 EDITION

Welcome to Astronomy 2002. For our lead article, Fred Watson from the Anglo Australian Observatory has returned this year to take us on a voyage of cosmological proportions. It is refreshing to see a discussion on cosmology that is clear and easy to understand, and doesn't degenerate into an endless stream of technical jargon. Fred is our yearbook's self-confessed No. 1 fan and we thank him for his support. We are also pleased to give the Sydney University Stellar Interferometer (SUSI) some recognition for its unique contribution to astronomy.

A positive aspect of doing this yearbook is the opportunity it presents to highlight the excellent work being done by fellow Australian enthusiasts. We hope you will be inspired by the Bob Evans interview. Bob is certainly one of Australia's most famous amateurs for his record setting supernova discoveries. Just as we were finalising this publication Bob found his 34th visual discovery in the well known barred spiral galaxy NGC1365 in Fornax. This is his second discovery in that galaxy!

Sydney astrophotographer, Joe Cauchi, also gives us a feel for his background in this technically demanding area of our hobby.

In the past, (up to 2000) we had included a section devoted to the Internet. This has been omitted again this year. We have instead decided to include this work on our upgraded website www.quasarastronomy.com.au.

With regards to observing in 2002:

- The Total Solar Eclipse in South Australia must take top billing (see article commencing on p. 13)
- The continual dance of the planets across the sky culminates in May this year with an early evening spectacular conjunction of all 5 naked eye planets.

This Eastern Australian Edition has been designed for observers anywhere in Australia, except Western Australia. A separate edition has been produced for Perth Observatory to cover W.A. Part I is intended as a general quick reference section for those wishing to see which planets are up tonight and when, during the year, is the best time to observe them. This section, in particular, is ideal for those just starting their exploration of the night sky. The 'Sky View' diagrams are an easy way for you to find your way around the night sky. The planets can be identified and followed throughout the year as these 'wanderers' journey through the constellations. Part II leans more heavily towards the needs of the seasoned amateur. Part III, the appendices, includes sections on astronomical places of interest and the amateur societies, ideal for the beginner. As in previous editions of this yearbook, the authors would like to conclude this introduction with a brief word to the novice. Astronomy, like any science, may seem to be swamped in jargon. Unfortunately, it is impossible to avoid such words. However, where necessary, astronomical terms have been explained in the text or covered in the glossary. To a beginner, some of this information (especially the tables of numbers) may seem difficult to understand. It is important not to allow yourself to become overwhelmed. Understanding will come with experience and when there is a need to know.

Wishing you clear skies and many hours of enjoyable observing.

Glenn Dawes Peter Northfield K e n W a l l a c e

ACKNOWLEDGEMENTS

Some of the information for this yearbook was adapted from the following sources:

- Astronomical Almanac for the Year 2002 (US Naval and Royal Greenwich Observatories)
- Astronomical Tables of the Sun, Moon and Planets (Jean Meeus)
- Comet orbital elements courtesy International Astronomical Union
- Fifty Year Canon of Lunar Eclipses 1986 - 2035 (NASA RP1216)
- Fifty Year Canon of Solar Eclipses 1986 - 2035 (NASA RP1178)
- Eclipse information based on predictions courtesy of Fred Espenak, NASA/GSFC
- Institut de Mecanique Celeste (IMCCE) - Paris Observatory for Jupiter satellite events
- Burnham's Celestial Handbook (Robert Burnham Jnr.)
- Dawes Meteorological Journal
- Guide to Observing the Moon (BAA)
- Moon Observers Handbook (Price)
- International Meteor Organisation Calendar

Data was also prepared with the assistance of the following computer software:

- MICA ver 1.5 (US Naval Observatory)
- Occult ver 4.2 (David Herald)
- Deep Space ver 5.56 (David Chandler Company)
- Voyager II, the Interactive Desktop Planetarium ver 2 (Carina Software)
- TheSky for Mac ver 5 (Software Bisque)

Special thanks are extended to John O'Byrne, John Davis, Michael Schwartz, Bob Evans and Daniel Tickell for their contributions. Also to Greg Bryant for the comet text and monthly comet highlights.

We would also like to thank the following for assistance in proofreading (certainly an important part of this complex publication): Greg Bryant, Brenda McNamara, Richard Jaworski,

Rob McIntyre, Elise Dott and Sue Dawes (typing and proofreading).

Illustrations

- The front cover, the Hydra Cluster of Galaxies (Abell 1060) and NGC 5128 (p. 10) were photographed by David Malin at the Anglo-Australian Observatory © AAO/D. Malin.
- Photographs by Sydney amateur, Joe Cauchi.
 - Title page is the globular cluster Omega Centauri (250mm $f/4$, using hypered Kodak 2415 film, exposure was 5 minutes).
 - Page 25 the images of the Trifid Nebula (250mm $f/4$, 12 mins, hypered 2415) and the Orion Nebula (250mm $f/5$, 12 mins, 103Ae film).
- Industrial Strength Cosmology (starting p. 5), figs 1 and 2 are courtesy NASA, fig 3 is courtesy 2dF Quasar Survey Team.
- Photo of Bob Evans (p. 9) supplied by Bob.
- Images in SUSI article (p. 12) courtesy John O'Byrne.
- Photo of Joe Cauchi (p. 29) supplied by Joe.
- Solar eclipse photographs by Peter Anderson, Queensland, from northern Zimbabwe 21 June 2001, using a Meade ETX 90 at $f/14$. Kodak ISO 100 print film and aluminised filter (partial phase, p. 15) and Kodak ISO 400 print film for the diamond ring, (front cover) and the total phase (p. 14)
- Comet C/2001 A2 (LINEAR) image (p. 41) by Gordon Garradd.
- Places of Astronomical Interest section; Magellan Observatory (p. 134) by Zane Hammond, and Wollongong Science Centre & Planetarium (p.133), courtesy Glen Moore.
- Rear cover photo is Comet C/2001 A2 (LINEAR) by Roger North, Kings Tableland Observatory (Takahashi 106mm $f/5$ refractor, 15 mins using Fuji 400).

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When you come to think of it, astronomy is a pretty daft business. Here we all are, insignificant microbes on the surface of a cinder left over from the formation of the Sun, trying to understand a Universe whose age and scale simply boggle our insignificant microbe brains. Of course, the more intelligent among us will have a copy of this book to help us find our way around the local suburbs, but you still have to admit that the whole enterprise is fairly barmy. No wonder astronomers are considered eccentric.

What is even more absurd is the idea that we think we understand how it all works. A Big Bang, about 13 billion years ago, to start it all off. And then everything else following with almost pre-ordained inevitability—from cometary globules and supernovae to planet Earth and the Teletubbies. This is big-time audacity on the part of the microbes.

We grace this audacity with a name—cosmology. It's defined as the study of the origin and evolution of the Universe as a whole. And, for a bunch of microbes, we seem to be doing rather well at it. So well, in fact, that Professor Malcolm Longair—a leading British cosmologist and former Astronomer Royal for Scotland—has recently described the modern era as the 'new realm of precision cosmology.'

It is not usual for your humble author—a former student of Longair's—to disagree with this eminent professor. (Can you imagine what it's like having an Astronomer Royal as your Ph.D. supervisor? In a word, terrifying—although I'm sure he would never have thought of himself as scary to his students.) However, I do think there is an alternative way to put it. The real hallmark of our current picture of the Universe is its *robustness*—its ability to stand up to increasingly-detailed scrutiny as new data are gathered. That is why I think we live in an era of 'industrial-strength' cosmology.

What has brought such resilience to our ideas on the origin and evolution of the Universe? Several things have contributed. On the observational side, scientists have been blessed with

copious quantities of new data as astronomical technology has improved. Bigger telescopes, better instrumentation, more advanced spacecraft. Taken together with a greater understanding of fundamental physics, they have strengthened our cosmological models. On the theoretical side, the models themselves have become more sophisticated as a result of the efforts of the super-brains, the Einsteins of our own generation. Hawking, Rees, Peebles, Sandage, Silk, Longair himself—these names are legendary to workers in the field today.

It is with some of the observational advances that this article is concerned—together with a few of the impressive strides that are just around the corner. But first, it is worth mentioning a rather neat distinction drawn by a colleague at the Anglo-Australian Observatory, Dr Joss Hawthorn. This rapidly-becoming-legendary scientist distinguishes between the cosmology of the near field and the cosmology of the far field. By the former, he means the history of our own Galaxy and other, nearby galaxies. These objects can be studied in great detail, and accurate inferences made about the processes that have taken place during their lifetimes. They act as models for more distant objects, whose evolution can then be better understood.

It is studies in the far field that most of us think of when we talk about cosmology—investigations of the most distant objects. They include very remote galaxies, highly-energetic quasars, and that newly-discovered and mysterious class of objects, gamma-ray bursters. Because of their great distances and the finite speed of light, we see such objects as they were billions of years ago. Far-field cosmology also takes in gravitational lensing (a handy tool for exploring the distant Universe, kindly provided by Professor Einstein) and studies of the oldest and most distant thing we can observe—the cosmic microwave background radiation, or CMBR.

Exploring the Cosmic Wallpaper

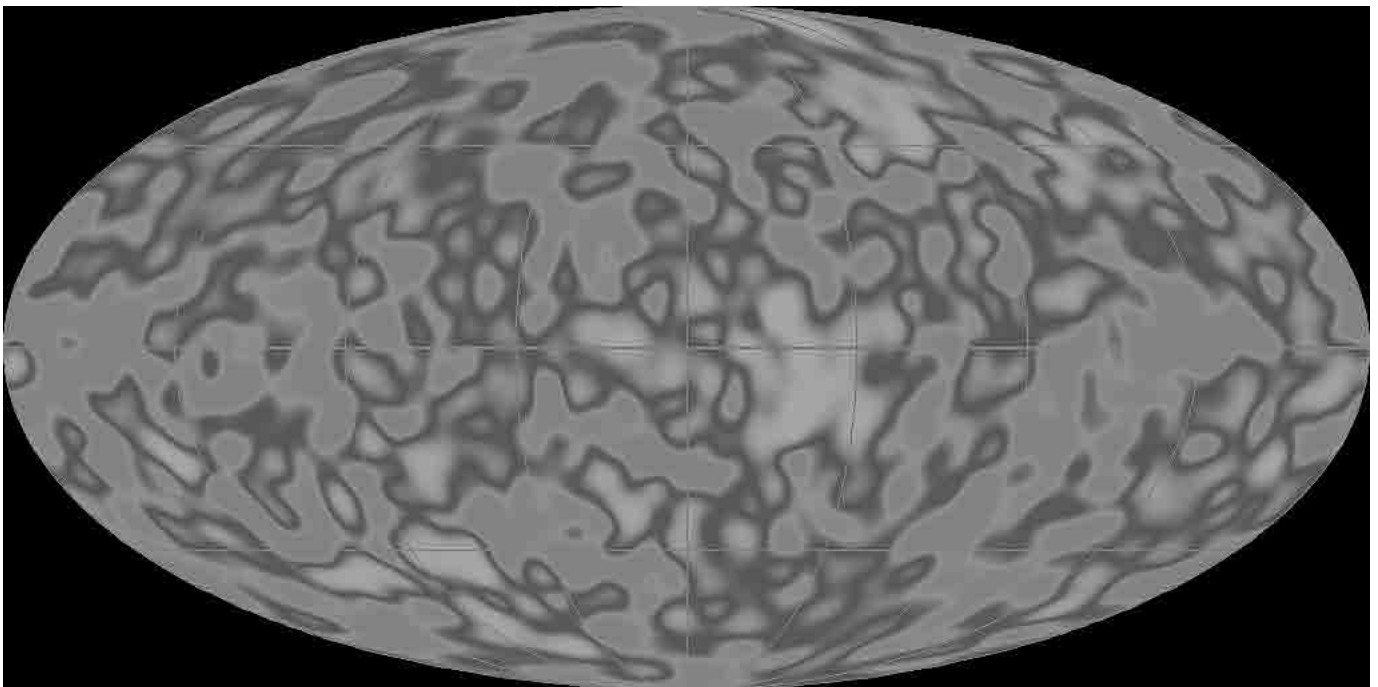


Figure 1. COBE's blurred view of the 'wallpaper'—the cosmic microwave background radiation. The whole sky is shown, and the ripples are the 1-part-in-100,000 variations in background temperature that represent the seeds of structure in today's Universe. COBE was insensitive to detail finer than about 7 degrees across on the sky. (Courtesy NASA.)

This stuff—the CMBR—became the clinching evidence for the Big Bang model of the Universe when it was accidentally discovered in 1965 by two engineers at the Bell Telephone Laboratories. They had found a weak signal in the microwave region of the radio spectrum that seemed to be coming from everywhere in the sky. In fact, it turned out that the whole sky was glowing as if it had a temperature of 2.7 degrees above absolute zero—and that something like this had already been predicted by the physicist George Gamow almost two decades earlier. Today, the CMBR is beginning to yield up its secrets, and has huge potential for increasing our understanding of the Universe. So what is it, and how did it get there? And why is it so important?

To answer these questions, you have to have some appreciation of what the Big Bang theory is all about. The name, incidentally, came from a derogatory remark made by Sir Fred Hoyle (a proponent of the rival Steady State theory) on BBC radio in the 1950s. But the theory owes its origins to work by Alexander Friedmann and Georges Lemaître back in the 1920s. Friedmann solved the mathematical equations of Einstein's general relativity to reveal the possibility of an expanding Universe, while Lemaître realised that expansion implies an initial creation event. In other words, at some time in the very distant past, the whole of space was compressed into a single point.

Today's theoretical picture of the Big Bang is a vastly more sophisticated affair. The so-called 'standard model' includes the following basic ingredients:

- a hot Big Bang explosion about 13 billion years ago, in which not only space but time, too, was created;
- an extremely brief period of violent inflation when the infant Universe was about 10^{-33} of a second old—followed by the steady expansion still taking place today;
- the existence of copious quantities of hidden material in the form of unknown particles (the so-called 'non-baryonic dark matter')—though the exact amount is one of the great challenges of modern cosmology;
- a gradual braking of the expansion by the mutual gravitational attraction of all the matter in the Universe (but whether it's enough to stop the expansion remains a moot point).

To this exotic mixture, current thinking adds a recycled version of an old idea—a cosmic repulsion, or vacuum energy (usually called the cosmological constant), that might actually cause the expansion to *accelerate*. The result is an intoxicating brew that intrigues observational cosmologists with its various uncertainties.

They, in turn, cite three basic observations in support of the model. First, the Universe is, indeed, expanding, as first demonstrated by Edwin Hubble in 1929. Then there is the fact that light elements such as helium and deuterium are found in the ratios predicted by the Big Bang model. Finally, and perhaps most dramatic of all, there is the existence of this cosmic microwave background radiation.

To understand the CMBR, you have to imagine the Universe when it was only a few hundred thousand years old. While some of the weirdest episodes of its early history—inflation, for example—were long past, it remained a very different place from today's Universe. Space itself was glowing brilliantly like an opaque fog of radiation—a fireball. Unlike today, there was no means of seeing through it.

Then, quite suddenly, when the Universe was about 300,000 years old, it became transparent. This article is too brief to go into the details of why this happened, but it took place

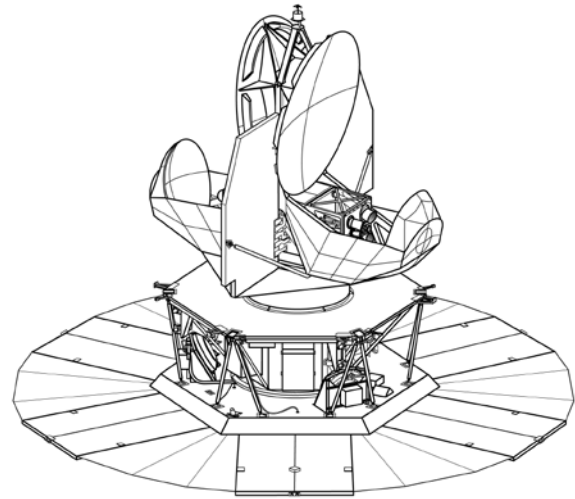


Figure 2. Line drawing of MAP. The prominent disc at the bottom is a sunshield supporting the spacecraft's solar panels, shown here in the deployed position. Above that is the main structure, surmounted by the two back-to-back Gregorian telescopes that focus microwave radiation from spots on the sky 140 degrees apart. Each telescope has a $1.4\text{m} \times 1.6\text{m}$ main reflector. MAP will sharpen our view of the cosmic microwave background by more than 20 times. (Courtesy NASA.)

everywhere over a very short period of time. Of course, the Universe is still transparent, and because of that—and because of the finite speed of light—we can now look back in time to the instant when the fog cleared. And what do we see? Yes, the ubiquitous cosmic microwave background radiation.

There is a well-known and rather neat analogy to explain why we can still see this cosmic fossil. Imagine yourself at an outdoor concert in a huge area packed with people. (I'll leave you to decide what kind of music you've been listening to...) At the end of the performance there is wild and enthusiastic applause, but the band (or whatever) signals an end to the cheering—and, instantly, everyone in the audience falls silent. Now, do you immediately hear silence?

The answer is no, because even though you and everyone else have stopped applauding, there is still sound on its way to you from your surroundings. One second after the applause stops you'll still hear the sound made by people 330 metres away just as they stopped cheering; a second later you'll still hear sound that came from people 660 m away—and so on. You are in the centre of an expanding circle of silence—and it is expanding at the speed of sound.

Similarly, we are at the centre of an expanding sphere of transparency in the Universe, and we are still receiving radiation that was emitted from the glowing fog almost 13 billion years ago. This expanding sphere is sometimes called the 'last scattering surface'. I suppose its equivalent in the terrestrial analogy might be called the 'last cheering circle'.

There is one important ingredient missing from the cheering analogy. In that picture, the sound you hear is at the same pitch as it was emitted. But that is not the case with the CMBR. When the radiation was emitted, it was brilliant white light, the product of a fireball at about 3000 degrees. But we perceive it today as weak radiation in the microwave region of the

spectrum. The reason for this is that the Universe is expanding, and the expansion has stretched the wavelength of the background radiation moving through it—in fact, by about a thousand times. It's a direct consequence of the expanding Universe.

One other attribute of the CMBR can be explained by the applauding audience analogy. Suppose the audience is composed of clumps of people who are slightly more or slightly less enthusiastic about the band than the average. When the cheering stops, some directions will have louder applause coming from them than others. These directions might well vary as the area of silence expands, but the basic idea remains—there will be structure in the 'last cheering circle'. That is exactly the case with the CMBR. Even though it is exceedingly uniform over the sky, it does have faint ripples—in fact, at the level of about one part in 10^5 . And it's just as well it does. Otherwise, folks, we wouldn't be here.

The Seeds of Creation

The ripples in the CMBR take the form of slight variations in the temperature of the fossil radiation. They arise from variations in density, gravity and velocity in the fireball all those billions of years ago. It was the British-turned-American astronomer Geoffrey Burbidge who pointed out in 1980 (before the ripples were detected) that they were the gravitational seeds of the earliest galaxies—and if they weren't there, neither were we!

The story of the detection of the ripples by the COBE spacecraft (cosmic background explorer) in the early 1990s is well-known

(see fig. 1). The CMBR anisotropy (its departure from uniformity) was measured by careful analysis of the COBE data by a team that included Dr Charley Lineweaver—now an astronomer at the University of NSW. What is less well-known, however, is the treasure-trove of cosmological information that is locked up in the ripples. If you analyse the characteristic scale of these hot and cold spots (in degrees on the sky), you can put limits on the local rate of expansion, whether or not the density of the Universe is enough to halt the expansion, whether or not the mysterious cosmological constant exists—as well as details of conditions within the fireball. Most of this information was well beyond the sensitivity of COBE, but several other projects since then have attempted (with some success) to make measurements.

Today, though, we are on the brink of a complete revolution in these studies. On 30 June 2001, a Delta II rocket, launched from Cape Canaveral, carried aloft a new spacecraft that will map the CMBR in unprecedented detail. Aptly called MAP (for Microwave Anisotropy Probe, see fig. 2), the spacecraft will measure the cosmic glow to about one part in a million (a few millionths of a degree K) on angular scales down to 0.3 degrees over the whole sky. As these words are being written, MAP is engaging in a complex series of manoeuvres that will use the slingshot effect of the Moon to place it in a stable orbit around the Sun about 1.5 million km beyond the Earth. Here, its remoteness from terrestrial microwave radiation will allow it to carry out the sensitive measurements required during its 27-month mission. And the results will certainly be worth waiting for. Look out for preliminary conclusions during 2003.

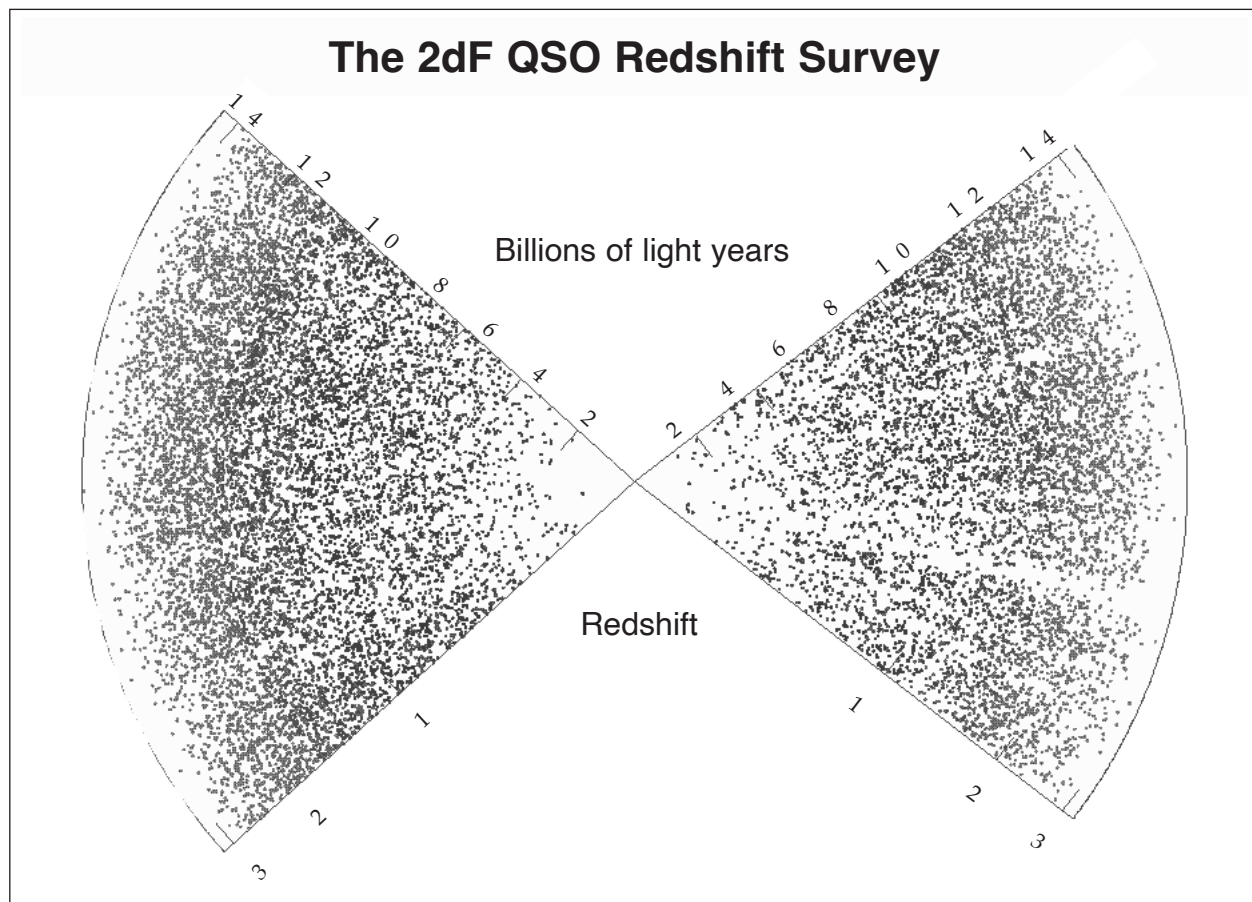


Figure 3. Cross-section of the Universe showing the positions of 11,000 quasars measured with the 2dF instrument on the 3.9-m Anglo-Australian Telescope. The two halves of the diagram represent the views to the north and south of our own Galaxy, which is at the centre. The distance calibration shown (in billions of light-years) is dependent on cosmological model and is probably overestimated at the largest values, but the clumpiness of the quasar distribution is beyond doubt. (Courtesy 2dF Quasar Survey Team.)

Meanwhile, back on Earth, there is more new evidence that ties down the details of the 'standard' picture—and it comes from our own Anglo-Australian Telescope (AAT) in NSW. Many readers of this book will have heard of 2dF (for two-degree field), a marvellous instrument on the AAT that allows the tell-tale signatures of celestial objects to be extracted from their rainbow spectra at an unprecedented rate. In fact, measurements can be made for up to 400 objects at once.

This formidable device has been making maps of its own—not of the CMBR, but of galaxies and quasars. A survey of the three-dimensional positions of a quarter of a million galaxies is now nearing completion. Though these galaxies range in distance out to about two billion light years, they essentially provide a snapshot of the Universe as it is today. Preliminary results announced during 2001 revealed that the level of clumpiness found in the distribution of the galaxies—their tendency to group together in clusters or strings—is entirely consistent with the best measurements of the ripples in the CMBR. In other words, the 'seeds of creation' imprinted on the Universe some 300,000 years after the Big Bang are still there today, frozen into the pattern of galaxies we see around us.

Moreover, another survey being carried out by 2dF confirms this view. About 25,000 quasars—vastly more energetic objects lurking in the cores of very distant (and therefore young) galaxies—are being mapped out to a distance of perhaps 12 billion light years (see fig. 3). On this large scale, too, the clumpiness is there, providing additional confirmation of (and constraints on) the Big Bang model. Professor Tom Shanks of Durham University in Britain, co-leader of the quasar survey, says 'The lumpiness we see at very large scales must be almost entirely determined by the conditions in the fireball of the Big Bang during the first second of the Universe's life.'

Despite the robustness of the cosmological models favoured today, there is still a healthy degree of scepticism among the scientists closest to the research. 'It's almost too good,' says Professor Brian Boyle, Director of the Anglo-Australian Observatory, of the agreement between the 2dF galaxy survey result and the CMBR anisotropy. And Dr Joss Hawthorn, piecing together evidence from both near-field and far-field observations, believes there could still be major flaws in our understanding of the early Universe.

Nevertheless, despite these misgivings, cosmology has progressed enormously since it was regarded as a branch of philosophy only a few decades ago. Today's industrial-strength version really does have a lot to recommend it. All in all, it's not a bad effort for a bunch of microbes.

Dr Fred Watson is Astronomer-in-Charge of the Anglo-Australian Observatory at Coonabarabran in central NSW, and an honorary Associate Professor of Astronomy in the University of Southern Queensland.

PLANISPHERE

A planisphere makes a great companion to our book. It is a hand held aid used to identify which stars and constellations are visible on any particular date and time. It is useful for many years.

The 'Night Sky' planisphere is a high precision, low distortion aid to the visual observer. It is double sided, designed for the southern hemisphere, and printed with a light background for easy night readability. Its plastic construction makes for a durable and moisture resistant product.

To use this planisphere is easy. Just turn the disk so the date lines up with the time and it will show you what the sky looks like now. It's that simple!

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BOB EVANS – SUPERNOVA HUNTER

INTRODUCTION

Rev. Bob Evans is a retired Uniting Church minister living in the Blue Mountains, west of Sydney. He is also one of the most famous amateur astronomers Australia has produced in the 20th century. With simple equipment, by today's professional standards, his discoveries of supernovae have contributed significantly to our understanding of one of the most violent events the Universe can create - the death of a star. When a star goes supernova it can for a number of weeks shine as bright as the combined light of all of the galaxy's stars. As an amateur Bob observes these faint galactic blobs (in most cases photographs or CCD images are needed to show the spectacular spiral arms of some galaxies) and looks for the appearance of new stars. The trick is to recognise a new star amongst the sometimes numerous fainter foreground stars which belong to our own galaxy, the Milky Way. His dedication and excellent memory of not just the field stars, but the positions in the sky of the thousands of galaxies he has observed, has been unequalled in this field. It is little wonder that his record of 38 discoveries has still not been surpassed (as of September 2001) and even when it is, the real record, 34 visual discoveries (as the recognised discoverer), may never be broken.

The following is an extract from an interview with Bob conducted by American amateur, and fellow supernovae hunter, Michael Schwartz when he was in Australia in January 2001. The uncut version is available on his web site www.tenagraobservatories.com

What most people don't know about Rev. Evans is that he is deeply interested in history, especially the history of religious revivals. His latest book specialises in those occurring in the United States in the 1830s. He has an extensive library that has taken over his garage and rather than being full of astronomy books it is populated with references about religions. People extraordinary in one area are often the same in others.

THE INTERVIEW

(M is Michael, B for Bob)

M: Bob, can you tell me a little bit about how you became interested in astronomy?

B: My father had been in the scouts years before I was born, and so he knew the names of a few stars and constellations. When I was about 9 or 10 he introduced me to these things. He brought home an old star atlas from the university library and so I learned the constellations from that and started observing with a pair of binoculars. When I was in my early teen years in high school my brother made a telescope for me out of a paper tube and a spectacle lens with a microscope eyepiece. I didn't own a proper telescope until I left school. At 18 or 19 years of age, that would be 1955 or '56, I bought a 2" refractor and a 5" reflecting telescope made by someone else. This reflector was just a tube and optics - no mounting. It took me 12 months to learn how to make the thing work.



Rev. Bob Evans with his 410mm telescope, with notches for each of his supernova discoveries made visually with this instrument since 1986.

I began to look at different types of objects in the sky. In those days I was able to observe 12th magnitude objects from the roof of our house in suburban Sydney. Of course the light pollution wasn't then anywhere as bad as it is now. In the mid '50s I began to read about supernova and considered the possibilities of supernova hunting. I started using the 5" telescope to look at galaxies. The telescope enabled me to see a good many bright galaxies, but it was too small to find supernovae in more than a few dozen galaxies. So it was about 1960 when I bought a 10" mirror to put into a telescope, but it didn't actually get made into a telescope until about 1966 after I'd been to college. So while I had the ambitions of finding a supernova in those early days, I never had a serious chance of finding one.

M: Had you ever thought about becoming a professional astronomer?

B: That was not a possibility for certain reasons, one was that I felt a call to do ministerial or missionary work and also because I didn't have any great mathematical skills. There were no jobs around in that area anyway.

M: Why supernovae? Why not variable stars? Why not drawing planets?

B: It just took my fancy.

M: Was there any relationship between your calling to evangelical work and your interest in the cosmos?

B: Not really, no.

M: They have always been two separate parts of your life?

B: Astronomy is a hobby. Obviously I have thought about science, religion and cosmology and related sorts of things but that wasn't the reason I became interested in astronomy. In fact, some years ago I wrote a philosophy book about it, although it is only a 'desk-top' production, at present.

M: When I say "Why supernovae?" there must be some reason that you considered it while there was an entire world of amateurs who apparently never gave it a thought. There were many other amateurs with 10" and 12" telescopes but no one else took that path.

B: As I said, I thought of looking for supernovae in the 1950's with the 5" telescope. But, at that stage, I was really just starting to make my first observations of galaxies, any galaxies. I knew that I was very unlikely to find a supernova until I had a larger telescope.

Only 50 or 60 supernovae had been found at that time. Naturally, they were mostly brighter ones found with the 48" Palomar Schmidt. The 1937 supernova in IC 4182 was 8th magnitude and a lot of the others were 10th and 12th magnitude, so there was a good possibility of seeing some of them with a 10" telescope from a reasonable site.

M: What telescope did you use for your first discovery?

B: The 10" telescope became functional in the late 1960s. It didn't get used much until we moved to the Lake Macquarie and Newcastle area, north of Sydney, because the place we lived in 1967 and 1968 was badly light polluted. It was hopeless trying to observe from there. The sky was not too bad around Lake Macquarie, and it became possible to increase the number of galaxies I observed. There were a number of false alarms of course, in the process of learning what the galaxies look like, and also due to the fact that there were very few good reference materials. There was only a modest range of photographs of southern galaxies available, and it was impossible for an amateur in Australia to get access to the Palomar Survey at the time. So the only thing to do with a lot of the galaxies was to make a drawing, and hope that next time you looked you didn't get the directions (north, east, etc.) wrong. But the difficulty too was that after I got used to seeing a galaxy a number of times I could see more detail. So my knowledge of the galaxies' appearance improved. Each time I looked, and some detail became observable, it was possible that the new feature was a supernova. It created quite a problem. So there were a number of false alarms. In addition, around 1970 there was no one to check

them out. There was no verification system. It was nearly impossible to relate the few existing photographs to what could be seen in the telescope.

M: It's still difficult for a lot of people trying to use different media whether it's a CCD picture against film, or film against the eye, HII regions can look star-like. All kinds of things look different from one medium to another.

B: So, to improve my verification system, in the early 1970s I tried to turn the 10" visual telescope into a photographic telescope. That was like trying to make a silk purse out of a sow's ear and it didn't work. So I gave up for the most part until 1980 when the news came about the supernova in M100 found visually by Gus Johnson.

M: So that was a particularly inspirational moment? You thought, "Ah, it can be done! I'll get back to it."

B: Yes that's right. But also, new dimensions and new possibilities were opening up. At that stage we lived farther up the coast in New South Wales, closer to Brisbane, and there were several amateurs in the Queensland organisation who were starting to make charts of galaxies for reference in supernova hunting. So I started working with them, using the prototype versions of their charts. Also, Tom Cragg (who was then chief night assistant at the Anglo-Australian Observatory) at Coonabarabran gave me access to the survey materials at the Anglo-Australian Observatory. Then I could make 35mm photographs of the galaxies from the ESO and Palomar surveys.

M: Then you went in and photographed the plate prints themselves?

B: Yes, parts of the plates. I used to travel up there from time to time and shoot off a day's worth of films.

M: So, by now you are a father, have an active ministry and you are trying to discover supernovae when the Sun is down. How did you manage this juggling act?

B: Oh well, the family was growing up. We lived in a small country town 400 miles up the coast from Sydney, with a very nice dark sky. All I had to do was put the telescope together on the back lawn and I could observe. Given that the resources for comparison were improving, I was able to make my first discoveries.

M: Tell me about your first discovery. Did you wake all the neighbours up by yelling in the back yard?

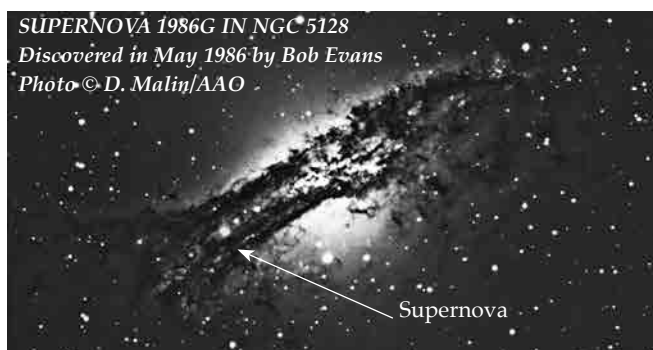
B: No, no, no. The first discovery was an unofficial one. A supernova appeared in NGC 1316, which is Fornax A. There was a photographic search being conducted in Chile at the same time. They took a photograph of this galaxy late November 1980, but they didn't look at their picture. Then they took another photo in the middle of December, and found the supernova. It was a day or so after that that I found it as an independent discovery. By the time Tom Cragg had verified it visually the announcement was out and there was no point in trying to claim I had discovered it.

M: None-the-less it was a discovery.

B: Well, it was as far as I was concerned. Early in 1981 we had some long service leave for a couple of months and we went out to one of the beach locations near where we lived. That was where the first of my official discoveries was made in the 10" telescope (in NGC 1532), just beside the beach. This telescope was easily portable.

M: How did you feel after making your first genuine discovery?

B: I was very moved that something had happened! But actually there were 3 bright supernovae that appeared in fifteen days. I discovered the first one, and made a pre-discovery observation of the second one, but mistakenly I decided that it wasn't a supernova. So a Russian astronomer found it the next day. I missed the one in the middle! But there was another supernova just a few days later in NGC 1316, the second supernova in that galaxy. I had gone out to Tom Cragg's place on Siding Spring Mountain and we found it there from his front driveway, with the 10" telescope. The discovery was verified visually straight-away and reported to the Central Bureau in a couple of hours, through our contact with the A.A.V.S.O.



M: It must have been very exciting after such a long wait.

B: Oh well, it was a change having 2 discoveries, yes. The team in Chile had also photographed NGC 1316 a number of times. They didn't look at their photographs, so they actually had a series of photographs, using several filters, I believe, which showed this second supernova rising from 20.5, 18.0, 16.5 and magnitude 16.0 on the way up in 4 nights. The visual discovery was made at magnitude 12.5. It was found just before maximum light.

M: So apparently having 2 discoveries in a relatively short amount of time whetted your appetite.

B: Well, yes, I would have continued searching anyway, but it helped. But I didn't find any more for 2 years. Then there were 4 discoveries in 1983 and 4 in 1984. So, by the end of 1984 I had 10 visual discoveries. The thing that set the ball really rolling was that two of the discoveries in '83 and '84 became the prototype examples of the newly recognised type 1b supernovae and another was later called type 1c. It was the supernova in M83, found quite a bit before maximum, which was studied in great detail, broke open the old classification system. It was also a radio object totally different from anything observed in radio beforehand. This helped create much further research in supernova studies. An identical supernova a year later (in NGC 991, and also a visual discovery) proved that a new class of supernova was involved.

M: It must have been very unusual for an amateur then to be on, what is now called, the 'leading edge of research'. Even today it can be difficult to find amateurs who are interested in pure science vs. taking pleasant looking pictures.

B: Yes. Well, there are still plenty who are simply interested in pretty pictures. I think that there always have been a number of amateurs who wanted to do some proper science. And supernova work is now a natural area for amateurs to choose, especially considering how the researchers have related supernova work to the new cosmological theories. It has quite a bit of appeal.

M: Now you had a total of 10 supernovae by the end of 1984 ...

B: There was 1 in 1985 and 3 in 1986. In January 1986, my 16" telescope came into use, as well.

M: That's pretty good production for visual work. I have always wondered why, during that time, you didn't have a Northern Hemisphere counterpart or even some competition in the Southern Hemisphere.

B: There were the beginnings of it. There were several Japanese photographic discoveries in those days. Some northern visual discoveries started to appear later in the 1980s. I think the problem was more that success depended on people having regular access to a dark sky site. Most amateurs live in cities. And of course they had to have their own reference resources.

M: Certainly your ability to remember star fields did not hamper you in your work. You also must have known how to get from one galaxy to another very quickly.

B: That is true, yes. Another aspect is that many of my supernova discoveries were recognised instantaneously, because I knew the fields so well.

M: I assume that if you have any talent remembering star patterns you can apply it to the entire sky therefore you didn't have to look at setting circles to get from one galaxy to another.

B: No, no. I used a straight-through finder and could locate most of the galaxies in a few seconds.

M: I had suspected that.

B: It was possible to observe 50 galaxies an hour when they were scattered around the sky, and 120 galaxies an hour in Virgo.

M: Let's talk about today's telescopes. The KAIT automated telescope can easily observe 1000 galaxies in a night. Under typical conditions about how many observations would you average a night?

B: It's not a question that can be really answered because I very seldom observed all night. I would only observe for a few hours at a time. I have observed all night on only a few occasions. Once back in 1984, using the 10", I observed out in the country for 10 hours and looked at 570 galaxies. That was an entire night near the equinox. It was in March, so it would have included Virgo but a lot of other constellations, too. With the experience I have now accumulated, and using a 16" telescope, I could probably observe over 1000 galaxies in one night, perhaps a winter night (nearly twelve hours here.) After all, 1984 was seventeen years ago.

M: So you actually can remember the one night when you had all night to observe?

B: Yes that was one occasion when I used the whole night. It was much more common for me to do quick runs for shorter periods. There was one occasion, a winter night (dark soon after six o'clock), and the Moon was going to rise at 10. It had been cloudy for a week, and it was probable that it was going to be cloudy for another week so I only had this one night, 4 hours really. In that time, I observed 336 galaxies, and then I found a supernova in the 337th galaxy. After the next week of cloudy weather I found another supernova. So in 1984 there were 2 discoveries in 8 days with no observing time in between.

M: When were you given the opportunity to use the 40" telescope at Siding Spring Observatory?

B: That was in 1995 through 1997. In 1993 we moved to Coonabarabran for church work. While I hadn't intended to use any of the professional telescopes, I wanted to see what could be done with a large telescope visually. In the end, the only thing I could do was apply for observing time on this (30 year old) 40" Boller & Chivens. Normally, this telescope is used almost every night for research. It meant open competition for observing time with professional astronomers, based on the scientific merit of the project. The allocation committee at Australian National University were generous with the observing time they gave us. Over a two years period, we had about 110 nights on this telescope. A lot of them were Moon affected, but half the nights were fine and we made 10,000 observations and found 3 supernovae and missed a couple. We saw other ones we wouldn't have seen otherwise.

M: How was that to jump visually from a 16" telescope to a 40" telescope?

B: Of course it brought a lot more galaxies into the range of an observing program. So I had to make a whole new set of pictures to have a full set of photographic resources. Moving the telescope around the sky was the time consuming thing which meant that only a couple of hundred observations could be done in a night which was not an enormously efficient use of my time considering I had to work during the day. I still used the 16" telescope at the same time in order to fill in the holes that couldn't be observed with the 40". There were a couple of discoveries made with that, from the backyard, as well. During this time, from 1983 to 1996, there were a number of visual amateur discoveries, including mine that paved the way for astronomers to refine their knowledge of type 1a supernovae.

M: Now we come to the time of the younger upstarts like myself with more complex equipment, CCD cameras etc. Given that we are operating this way, how do you see the future? Do you think that the automated systems lose something that you gain, or vice versa?

B: It is possible, in the short term, for there to be so many observers with automatic equipment, all searching for supernovae, that visual amateurs will be largely out of business, so far as making discoveries is concerned. That could happen simply by the number of observations being made. But there are so many galaxies, and so many variable stars, that visual observers will still be able to perform a role. Increasing technology will certainly make competition more difficult for visual observers. But, it is hard to see how all of the visual observers will be reduced to impotence completely. Visual observers will always be able to poke around and just look at the pretty sights. Variable star observers, comet hunters, and supernova and nova hunters will still conduct serious searching, even in the face of overwhelming competition. While they do all those things, there will always be the chance of finding something, however small. After all, the chances of making a discovery visually have always been small.

M: I think that the time for the automated telescope is here for lots of reasons. Humans don't have the time, staying power or the interest to observe all night every night.

B: Yes, they can't do what the computerised telescope can do, although even that has only been very recent.

M: That comes to a point I have often considered: What is it that makes supernova searchers different from other amateurs? I have called them the 'steppenwolves' or lone wolves of astronomy because it takes so much stick-to-it-iveness. It is natural for human beings to want to be paid for their efforts a lot more quickly than supernova searchers are.

B: (chuckling) Bill Bradfield (another famous Australian amateur, ed) was a lone observer like that, but he looked for comets. You somehow have to have it in you that you don't quit.

M: Do you have any particular words you'd like to leave for all the would-bes and will-bes out there? Your example has been an inspiration.

B: I don't think that the visual record will be surpassed for a while. Not while the automated searches are going. The visual record, I believe, will stand for quite some time. However, I believe quite firmly that there should be four or five records, or even more. There should be one record for visual discoveries. There should be another for photographic discoveries. There should also be a record for computer-assisted discoveries which were not fully automatic. And there should be another discovery record for fully automatic searching. I believe it is a mistake to compare your tally of discoveries with mine, or your tally of discoveries using computer-assistance with a tally made with complete automation. The work involved in each case is very different. How could anyone compare a discovery made by one's computer, while the so-called observer was asleep, with anything made by active observation of the sky? One is a triumph of computer technology applied to astronomy where the observer might not even need to know where any object in the sky might be found (like many professional astronomers today). The other is the result of direct observing of objects of known place and appearance in the sky.

M: The poets and light-hearted astronomers are not made and maintained by computers.

B: Yes, indeed.

M: I have genuinely enjoyed finally meeting you and appreciate your willingness to share your story and ideas.

B: You're quite welcome. It has been a pleasure for me as well.

Those of you who wish to contact Rev. Robert Evans may e-mail him at: "Robert Owen Evans" <bobevans@pnc.com.au>

The story of stellar interferometry really started back in 1920 when American physicist Albert Michelson made the first measurement of the size of a star using small mirrors attached to the 100-inch Hooker telescope on Mt Wilson in California. His technique relied on the telescope to combine the starlight collected by two small mirrors in such a way that the light beams 'interfere' with each other to produce bright and dark bands, known as interference fringes, across the image of a star. By varying the separation of the two mirrors until the fringes disappeared he succeeded in measuring the apparent size of Betelgeuse, the bright red supergiant star in the constellation of Orion. This was equivalent to measuring the diameter of a human hair at a distance of 100 metres! In spite of this achievement, problems posed by turbulence in the Earth's atmosphere, and by the extraordinary requirements for mechanical stability imposed by the wavelength of light, meant his efforts to extend his technique to more than half a dozen giant stars were thwarted.

Some 40 years later, Professor Robert Hanbury Brown, and colleagues, from the University of Sydney, built the Stellar Intensity Interferometer near Narrabri in northern NSW. The new technique employed in this instrument side-stepped the problems that defeated Michelson and, amongst a number of observational achievements, the diameters of 32 hot stars were measured, making an important contribution to stellar astrophysics. Many of the results obtained with the Stellar Intensity Interferometer have yet to be superseded.

Another 40 years on and the University of Sydney is still in the vanguard of stellar interferometry with SUSI. SUSI is also located near Narrabri - alongside the Australia Telescope radio array at the CSIRO's Paul Wild Observatory. SUSI has resurrected Michelson's original technique, but uses developments in lasers, optics, detectors and computers to overcome the problems that had frustrated efforts to develop the technique for some 70 years.

SUSI looks nothing like a conventional telescope. It has a 640 metre long North-South array of eleven 20 cm diameter steerable mirrors, called siderostats, that direct starlight via fixed mirrors and evacuated pipes to a central laboratory where the beams from two selected siderostats at a time can be combined for observations. Before the beams are combined their paths from the star to the point of combination must be made equal to within a very few millionths of a metre – if the paths are not matched the measurements will be erroneous at best and, since interference fringes may not even be seen, it may not be possible to make measurements at all. Matching the light paths is probably the

most challenging problem that has been solved in SUSI since the paths prior to reaching the two input mirrors can differ by many tens or even hundreds of metres depending on the separation of the two input siderostats and the direction of the star in the sky. The difference in paths is also changing as the Earth rotates so that matching the total path lengths involves varying internal path lengths over a range of speeds with exceptional smoothness and accuracy.

Turbulence in the Earth's atmosphere is the cause of 'seeing', the term astronomers use to describe the blurring of images formed by telescopes. SUSI overcomes the deleterious seeing effects of atmospheric turbulence by using small mirrors, stabilising the jittery motion of the two beams of starlight before they are combined, and sampling the intensity of the combined beams every one-thousandth of a second. Because any residual seeing effects would result in errors in the measurements made with SUSI, a number of techniques were developed during the commissioning of the instrument for measuring the magnitude and speed of change of the distortions in the incoming wavefronts of starlight. These measurements are now made routinely and simultaneously with the interference fringe measurements, thus providing valuable data that are used in calibrating the observations to ensure their accuracy. When the programme started it was not known whether the effects of wavefront distortion would continue to increase in magnitude out to 640 metres, the longest baseline of the instrument, thus making observations with the longer baselines extremely difficult compared with those at shorter baselines. SUSI has been used to show that while the effects increase rapidly up to around 10 metres, they gradually settle to a maximum value at about 80 metres making interferometry with the longer baselines no more difficult than at 80 metres.

SUSI has achieved a major design objective of making high accuracy (2% or better) measurements of stellar diameters. For example, the faintest star measured with the Stellar Intensity Interferometer, δ Canis Majoris, has been measured with an accuracy of 1.9%, a factor of seven improvement over the 14% accuracy of the earlier measurement. The measured diameters of stars are combined with data from conventional telescopes to yield important stellar parameters including effective temperature, true diameter and luminosity. One of the results of the Stellar Intensity Interferometer programme was to discover that a number of stars, thought to be single, were in fact double stars. Unfortunately, it was not possible to measure their separation with the Stellar Intensity Interferometer but they are being observed with SUSI to determine the separations of the component stars as a function of time so that their orbits can be determined. For example, β Centauri, the fainter and bluer 'Pointer' to the Southern Cross, which was found to be a double star with the Stellar Intensity Interferometer, has had its orbit determined with SUSI. The two stars making up β Centauri are very nearly equal in brightness, differing by only 15%, and orbit around one another every 357 days. The importance of observing binaries with SUSI is that the results, when combined with spectroscopic observations, yield accurate measurements of stellar masses and the SUSI group is collaborating with astronomers around the world in this work. The distances to binary systems can also be determined with an accuracy significantly better than has been obtained with the Hipparcos astrometric satellite by combining the SUSI measurements with spectroscopic data. SUSI is engaged in a number of observational programmes but an exciting one that is planned for the next 12 months involves measuring Cepheid variable stars as they expand and contract. Combined with spectroscopic



SUSI seen from the north end of the 640m baseline.

measurements, this can yield the distances of these important 'distance markers' of the galaxy.

Over the past decade the field of optical interferometry has blossomed with a number of instruments coming into operation. After a long period of development in which SUSI has played a major role, the scientific results are flowing. SUSI has the longest baseline array of any instrument, existing or planned, giving it the highest resolving power – the equivalent of being able to measure the diameter of a human hair at a distance of 100 km! The addition of a new optical system, currently nearing completion, to operate at the red end of the spectrum to complement the existing 'blue' system, will provide a significant improvement in sensitivity and versatility.

The construction and operation of SUSI has been funded jointly by the Australian Research Council and the University of Sydney and, given secure funding, SUSI will continue to measure stars with unprecedented accuracy as optical interferometry enters its next 40 years.



A siderostat station, showing the 20cm mirror in its alt-az mounting (the siderostat), which feeds starlight into one of the north or south periscopes mounted on either side of it.

IN THE SHADOW OF THE MOON - December 4th 2002

(A Guide to Observing the South Australian Total Solar Eclipse)

On the 4th December 2002, the Sun will be totally eclipsed by the Moon. This total eclipse is special in that it is visible from Australia, the first in over a quarter of a century. As the shadow of the Moon sweeps across the Earth at around 1600 km per hour, people from the far reaches of our planet will gather under the narrow path of totality to witness one of nature's most extraordinary and exquisite events.

The path of totality begins off the West Coast of Southern Africa and makes first landfall over Angola. Briefly crossing Zambia and Namibia, the path follows the Zimbabwe-Botswana border and exits the continent at Mozambique.

The track then begins the long journey across the Indian Ocean before reaching the South Australian coastal town of Ceduna. This historic moment marks the first time since 23rd October 1976 that the path of totality has touched Australian soil. The shadow continues beyond Ceduna across predominantly inhospitable outback terrain, passing just north of Woomera and finally ending in Queensland when the Sun sets, just beyond where the Queensland, New South Wales, and South Australian borders meet (see figure 1).

Figuratively speaking this eclipse is in our own backyard, however there are some vast distances to be covered; the township of Ceduna for example is 775 km from Adelaide, a good day's drive. If motoring from interstate we would advise some careful planning before the trip. The main viewing sites, although remote for the majority of the Australian population, are at least accessible.

The Australian outback is a harsh and arid environment, and even in early summer temperatures of 40°C and over are possible. The following simple rules for outback travel should be observed: stay on main roads, carry ample water, check road and weather conditions before travel, do not leave your vehicle if a breakdown occurs, and with service stations few and far between make sure you have sufficient fuel. In addition, you should leave details of your travel plans with someone else, particularly if travelling off the main roads.

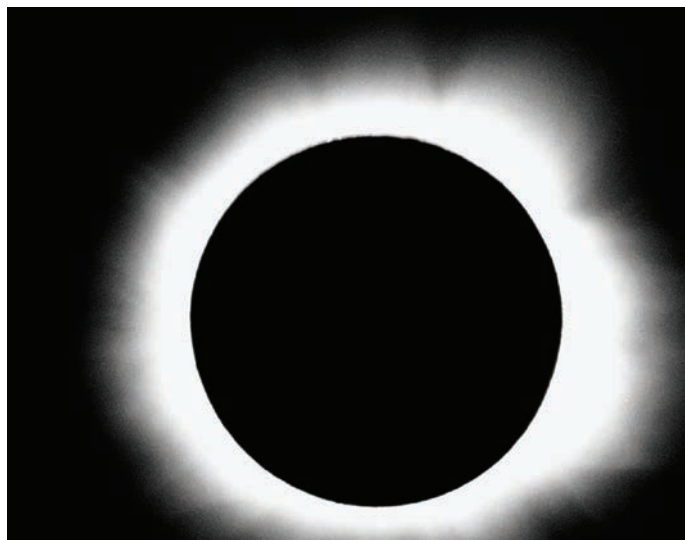
From South Australia, this sunset eclipse is short and low to the horizon. These two factors do not make for a perfect eclipse, but arguably even 30 seconds of totality at any altitude is better than nothing. Another quandary with this eclipse is that there are only three locations easily accessed for viewing. Should the weather deteriorate at a particular spot, there will not be enough time to reach another site on the day, the distances are simply too vast.

Accommodation near the path has been booked out for over a year, so late planners may need to search further afield. This is perhaps not a bad thing and accommodation near the Port Augusta region, at the head of Spencer's Gulf, will at least place the eclipse chaser at the crossroads to each of the possible viewing sites. A base such as this

will provide time to evaluate the weather conditions and make a final dash to your preferred site. Many will simply choose to 'rough it' in tent or vehicle, ready and mobile for a quick departure to the clearest skies.

The coastal town of Ceduna (figure 3) will probably entice most eclipse watchers, particularly those from overseas. Ceduna is located on the eastern side of the Great Australian Bight on the attractive shores of Murat Bay, around 470 km from Port Augusta and 775 km from Adelaide. To the west, the next major town, Norseman is 1200 km away, and Perth 1960 km. Ceduna is a stopover en-route to Western Australia, and caters well to travellers with all facilities available.

Woomera (figure 4) is another option lying 485 km from Adelaide and 180 km from Port Augusta. However, the path does not directly pass over Woomera, but rather about 70 km west of the town along the Stuart Highway near Wirraminna, a rail siding on the Trans-Australian Railway. An alternative site is on the Roxby Downs Road about 45 km north of Woomera near Purple Downs station. The nearest facilities to Wirraminna and Purple Downs are back at Woomera, where all facilities are available. The final possibility is just north of the small town of Lyndhurst, 290 km north of Port



Solar Eclipse from Northern Zimbabwe 21 June 2001 (Total Phase) by Peter Anderson, Queensland

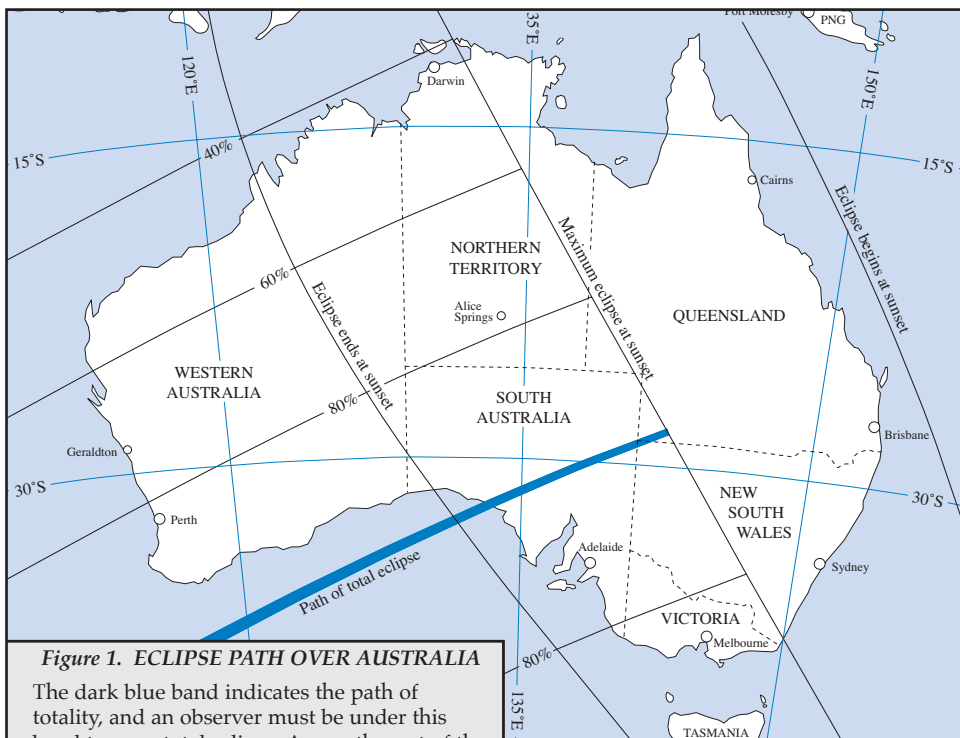


Figure 1. ECLIPSE PATH OVER AUSTRALIA

The dark blue band indicates the path of totality, and an observer must be under this band to see a total eclipse. Across the rest of the continent, varying degrees of a partial eclipse will be seen. For the partial phases; If situated left (west) of the 'Eclipse ends at sunset' line, the eclipse will be seen in its entirety. If on the 'Maximum eclipse at sunset' line, an observer will see the eclipsed Sun set during maximum or mid-eclipse. Between this line and the 'Eclipse ends at sunset' line the Sun will set before the partial phases are over. On the 'Eclipse begins at sunset' line, no part of the eclipse can be seen. If left (west) of this line (and before the 'Maximum eclipse at sunset' line) the partial phases prior to maximum or mid-eclipse will be seen before the Sun sets. The lines running parallel to the total path indicate the percentage of the Sun's diameter eclipsed by the Moon. The further from the total path, the less of the Sun is covered by the Moon.

A very simple and safe method to watch the partial progress of the eclipse is to project the Sun's image through a small hole onto a screen. A hole 1 to 5 millimeters in diameter should be made in a piece of stiff paper or card (alternately drill a hole in a piece of thin metal sheet). The image of the Sun is then projected through this hole and viewed against a screen of white paper or board. The screen should be held about 20 cm behind a 1 mm hole, and about 1 to 1.5 meters behind a 5 mm hole.

Along the same theme, but with a magnified and clearer image, is the eyepiece projection method with a telescope. The projection method is low-cost and easy (providing you have a telescope to start with), and enables more than one observer to monitor the progress of the eclipse. It is preferable to use a Ramsden or Huygenian eyepiece or any old cheap unwanted eyepiece. The intense heat at the focal point can damage eyepieces with cemented elements. Detail in sunspots can be discerned with this method, and a projected image around twice the diameter of the objective provides excellent results.

Direct observation through an instrument using filters is quite safe, provided the filters are specifically designed for this purpose. These filters are fitted to the *front* of the telescope, and are usually either aluminium coated Mylar or nickel chromium coated glass. The economical Mylar filters do show the Sun in an unusual blue light, whereas the expensive glass filters provide a pleasant yellow/orangish image.

Augusta. At the start of the Strzelecki Track, the Lyndhurst area is the least favoured site with the eclipse at very low altitude.

As the crow flies, from Ceduna, the distance to Wirraminna is 260 km, Purple Downs 340 km, and Lyndhurst 500 km. The further from the coast, the lower the Sun and Moon to the horizon: from Ceduna 9° altitude, Wirraminna and Purple Downs 6°, and Lyndhurst 4°. The duration of totality also reduces further inland, but is of less concern than the altitude loss. From Ceduna, you can expect 33 seconds of totality and from the Lyndhurst region 27 seconds (see table 'Eclipse Mapping Coordinates' on p. 16).

The Sun can be extremely dangerous unless you are experienced and familiar with safe solar observing techniques. The Sun requires special filters to observe with the unaided eye, or optical equipment. Its visible surface, the photosphere, not only radiates normal white light but also invisible ultraviolet (UV) and infrared (IR) radiation. Even when the Moon covers a substantial portion of the Sun, and the brightness is reduced to a comfortable level, UV and IR is still being radiated at dangerous levels. It is these invisible components of sunlight that damage the eye's retina. Directly looking at the Sun, even for a few seconds, can cause irreparable damage or blindness.

Avoid the use of photographic neutral density filters (of *any* density), smoked glass and exposed photographic film; these can transmit UV and IR radiation. Perfectly safe for the partial phases are purpose made, hand held aluminium coated Mylar filters, which can be purchased already supported in a cardboard frame, and even 'spectacles' are available. A number 14 welder's filter also will work. These products are useful for checking the Sun at any time for large sunspots.

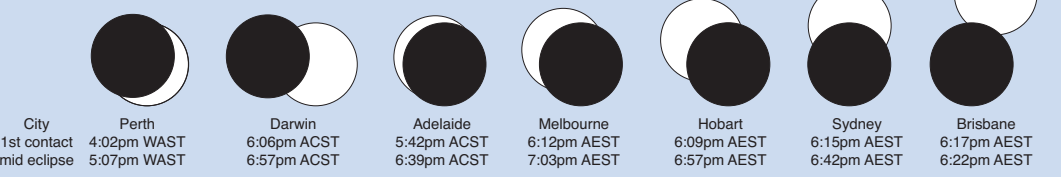
glass filters provide a pleasant yellow/orangish image.

If you intend watching the evolution of sunspots across the solar disk as a future long-term interest, the nickel chromium coated glass filters are recommended. **NEVER** use filters that go over the eyepiece, they can crack with the now focussed intense heat, allowing the highly magnified Sun's heat through. Ensure any filter is fastened securely, and do not forget to cap the objective lens of the finderscope, a likely source of a nasty burn!

During totality, AND ONLY AT THIS TIME, it is perfectly safe to view the event with the unaided eye or optical equipment. IT IS NOT SAFE to view directly the Bailey's Beads or diamond ring with any unfiltered optical aid. If you have any doubts on how to view the Sun in perfect safety, do not take any chances, it is simply not worth any loss of vision.

If you intend to photograph the eclipse, spend time in the weeks before the big day doing practice runs. Make sure your equipment is pointing to the same altitude as it will be on the day, so you become thoroughly familiar with all the controls in this positioning. Most camera lenses and telescopes are suitable for eclipse photography, but like any form of astrophotography a steady platform, tripod or mount is essential. Since the outer corona is visible out to one or two

Figure 2. The partial phase of the eclipse from outside of the totality zone for various locations. The appearance from Sydney and Brisbane are shown 10 mins before sunset, prior to mid-eclipse, other locations are at mid-eclipse when the maximum amount of the solar disk is covered. For Perth 4th contact (end of eclipse) is 6:09pm WAST.



solar diameters, the field of view in telescopes or telephotos should cover several degrees.

Telephoto lenses and telescopes in the 200 to 2000 mm focal length range will give good results, and even a standard 50 mm camera lens is useful for photographing the changing landscape. In fact, the shadow bands and projected crescent images of the eclipse through gaps in tree foliage are best with the 'standard' lens on a SLR camera.

Allow a few seconds between exposures to let vibration dampen out, and use a cable release. It is best to settle for a few good shots than numerous blurred exposures. The exposure guide (page 16) is just that, a guide. Natural sky filtering and other factors will influence these recommendations. With totality so brief, you will need to work calmly and systematically, so plan each exposure as if it were your last frame.

Image size on film is all-important and is determined by the focal length of the lens or telescope used. The longer the focal length, the larger the image, the larger the image the better it is for blowing up. To determine the image size, simply multiply the effective focal length of your instrument, in millimetres, by the diameter of the Sun/Moon in seconds of arc (1,800"), then divide the result by 202,265; the resultant answer is the image size in millimetres.

If applying the above formula to a 50mm lens, we get an image on film a little less than half a millimetre ($50 \times 1,800 / 202,265 = 0.44\text{mm}$); certainly not an acceptable size for detail or enlargement. Moving up to a 500 mm lens things improve ($500 \times 1,800 / 202,265 = 4.45\text{mm}$), and a 15 times enlargement will deliver an image about 68 mm in diameter. Working with the popular 2,000mm Schmidt-Cassegrain telescopes we achieve ($2,000 \times 1,800 / 202,265 = 17.80\text{mm}$), an ample image size for enlargement.

While we are talking about trial runs, if possible, it might be advisable to find your observing site a day or two before the event. With the eclipse occurring so low in the sky, it is not a good time to discover 30 minutes before totality that the Sun is going behind a hill! Take careful note of the where the Sun will be relative to the horizon and its local altitude at the time of totality. The Sun during totality will be very close to WSW (also see Sky View p. 71). This can be an opportunity to be a little artistic, especially if you are including a reasonably wide-angle lens in your arsenal of cameras e.g., put the Sun below the limbs of a dead tree? Can you get the eclipsed Sun and its reflection in a lake? Your imagination is the limit.

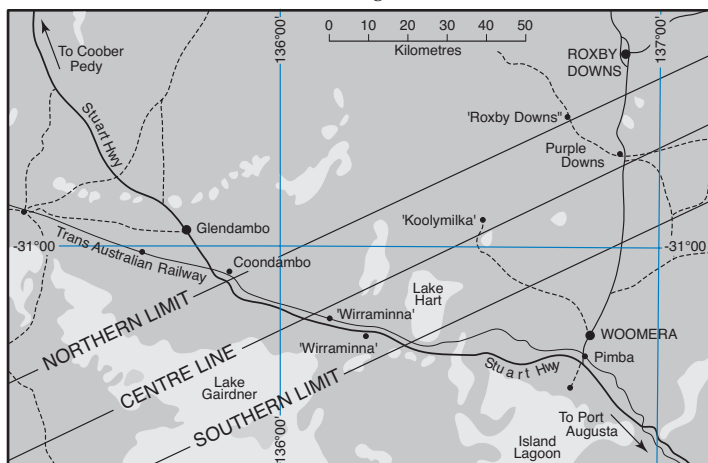


Figure 4. Woomera and surrounds. Much of the area north of the Trans Australian Railway and west of the Woomera/Roxby Downs road is the Woomera Prohibited area.

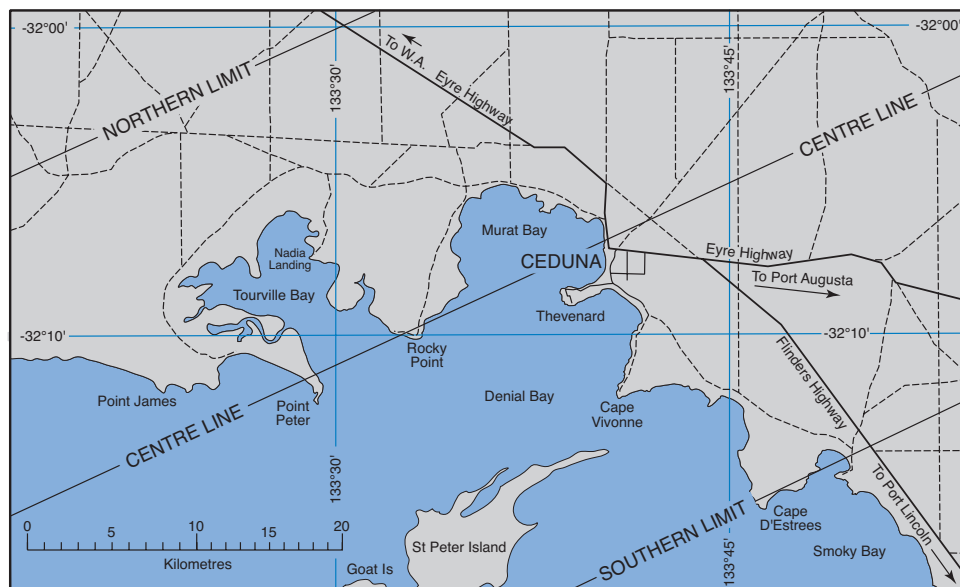


Figure 3. Ceduna and surrounds. Roads shown as solid lines are sealed main roads, dashed are unsealed main and minor roads. The centre line passes almost directly through the centre of Ceduna and there are many vantage points including several with scenic views across the bay.

What can you expect to see? Firstly, the eclipse begins as the Moon makes a slight indentation on the western limb of the Sun (point of first contact). From Ceduna this will occur about 5:43pm ACST (6:43pm daylight saving time). For the next hour, the Sun's disk diminishes steadily as the black body of the Moon passes over it. Nervous watchers waiting for the ephemeral moment of totality will be making last minute checks of cameras and telescopes.

Near totality, with the Moon covering most of the Sun, the surrounding landscape starts to turn an eerie gray, with shadows disappearing. The temperature begins to drop and a breeze develops. With solar eclipses, higher in the sky than the Australian one, it is normally worthwhile looking for thousands of tiny crescents visible on the ground beneath the trees. The small gaps in the foliage act in the same manner as a pinhole camera. Perhaps in December it might be worthwhile looking for the effect in shadows of trees on nearby walls of buildings? Gray shadow bands rippling across the ground are also seen during eclipses. This is an effect of atmospheric turbulence.

Only seconds before totality, the umbra of the Moon's shadow can be seen racing across the countryside. The Sun's limb abruptly breaks into a series of tiny bright beads. Known as Bailey's Beads, they are formed as the Sun shines between mountain peaks and craters on the lunar limb. A phenomenon known as the diamond-ring effect appears as the last bead appears ring-like together with the Sun's inner corona.

After the beads vanish (second contact), the Sun's inner atmosphere, the chromosphere (meaning 'colour sphere') appears for a few seconds as a reddish zone around the lunar limb. At this point, when totality begins, it is safe to view the Sun without any filters. The elusive prominences are now easily seen, projecting out from the limb in all their red and pink splendour. Then the Sun's faint tenuous outer atmosphere, the corona, appears, surrounding



Solar Eclipse from Northern Zimbabwe 21 June 2001 (Partial Phase) by Peter Anderson, Queensland

the Moon's black silhouette. The pearly white corona displays a petal structure, much like a flower.

All too soon, the display nears its end with the chromosphere reappearing. A bright bead of sunlight becomes visible through a lunar valley (third contact - totality ends). Suddenly, in a burst of glory, the diamond ring reappears and unprotected (unfiltered) eyes should be averted IMMEDIATELY. The Bailey's Beads return as the photosphere streaks around the western limb. The uneventful, anticlimactic partial phase again takes over, and animals, birds and insects, confused by a false brief twilight, return. The day ends with the Sun and Moon setting, still in partial eclipse.

The next total solar eclipse over our continent will be on 13th November 2012, passing over Cairns, Queensland.

The Earth's Moon is unique; no other planet has a satellite that matches the angular size of the Sun so closely. The Sun's diameter is about 400 times that of the Moon, but since the Sun is about 400 times further away their diameters match neatly. We are indeed fortunate to be able to stand under the shadow of the Moon, and witness one of nature's most spectacular and unforgettable events.

Eclipse Mapping Coordinates

Longitude	LATITUDE			CIRCUMSTANCES ON CENTRE LINE			
	Northern Limit	Southern Limit	Centre Line	Universal Time	Sun		Path Width
					Alt	Azi	
130° 00.0'	33° 21.38'	33° 45.68'	33° 33.49'	09:09:11	12°	251°	41km
130° 15.0'	33° 15.67'	33° 39.81'	33° 27.69'	09:09:17	12°	251°	41km
130° 30.0'	33° 09.93'	33° 33.92'	33° 21.88'	09:09:23	12°	251°	40km
130° 45.0'	33° 04.18'	33° 28.01'	33° 16.05'	09:09:29	12°	251°	40km
131° 00.0'	32° 58.42'	33° 22.09'	33° 10.21'	09:09:34	11°	251°	40km
131° 15.0'	32° 52.64'	33° 16.15'	33° 04.35'	09:09:40	11°	251°	39km
131° 30.0'	32° 46.84'	33° 10.19'	32° 58.47'	09:09:45	11°	250°	39km
131° 45.0'	32° 41.03'	33° 04.22'	32° 52.58'	09:09:51	11°	250°	39km
132° 15.0'	32° 29.37'	32° 52.24'	32° 40.76'	09:10:01	10°	250°	38km
132° 30.0'	32° 23.52'	32° 46.22'	32° 34.83'	09:10:06	10°	250°	38km
132° 45.0'	32° 17.65'	32° 40.20'	32° 28.88'	09:10:11	10°	250°	38km
133° 00.0'	32° 11.77'	32° 34.15'	32° 22.92'	09:10:16	9°	249°	37km
133° 15.0'	32° 05.88'	32° 28.10'	32° 16.95'	09:10:20	9°	249°	37km
133° 30.0'	31° 59.97'	32° 22.03'	32° 10.96'	09:10:25	9°	249°	37km
133° 45.0'	31° 54.05'	32° 15.95'	32° 04.96'	09:10:29	9°	249°	37km
134° 00.0'	31° 48.12'	32° 09.85'	31° 58.95'	09:10:33	8°	249°	36km
134° 15.0'	31° 42.18'	32° 03.74'	31° 52.92'	09:10:37	8°	249°	36km
134° 30.0'	31° 36.22'	31° 57.62'	31° 46.88'	09:10:41	8°	249°	36km
134° 45.0'	31° 30.25'	31° 51.49'	31° 40.83'	09:10:45	8°	248°	35km
135° 00.0'	31° 24.27'	31° 45.34'	31° 34.77'	09:10:49	7°	248°	35km
135° 15.0'	31° 18.28'	31° 39.19'	31° 28.69'	09:10:52	7°	248°	35km
135° 30.0'	31° 12.28'	31° 33.02'	31° 22.61'	09:10:56	7°	248°	35km
135° 45.0'	31° 06.27'	31° 26.84'	31° 16.51'	09:10:59	7°	248°	34km

Longitude	LATITUDE			CIRCUMSTANCES ON CENTRE LINE			
	Northern Limit	Southern Limit	Centre Line	Universal Time	Sun		Path Width
					Alt	Azi	
136° 00.0'	31° 00.24'	31° 20.65'	31° 10.40'	09:11:02	6°	248°	34km
136° 15.0'	30° 54.20'	31° 14.44'	31° 04.28'	09:11:05	6°	248°	34km
136° 30.0'	30° 48.16'	31° 08.23'	30° 58.16'	09:11:08	6°	248°	33km
136° 45.0'	30° 42.10'	31° 02.01'	30° 52.02'	09:11:11	6°	247°	33km
137° 00.0'	30° 36.04'	30° 55.77'	30° 45.87'	09:11:14	5°	247°	33km
137° 15.0'	30° 29.96'	30° 49.53'	30° 39.71'	09:11:16	5°	247°	33km
137° 30.0'	30° 23.87'	30° 43.27'	30° 33.54'	09:11:19	5°	247°	32km
137° 45.0'	30° 17.78'	30° 37.01'	30° 27.36'	09:11:21	5°	247°	32km
138° 00.0'	30° 11.67'	30° 30.73'	30° 21.17'	09:11:24	4°	247°	32km
138° 15.0'	30° 05.56'	30° 24.45'	30° 14.97'	09:11:26	4°	247°	31km
138° 30.0'	29° 59.44'	30° 18.16'	30° 08.76'	09:11:28	4°	246°	31km
138° 45.0'	29° 53.31'	30° 11.86'	30° 02.55'	09:11:29	4°	246°	31km
139° 00.0'	29° 47.17'	30° 05.55'	29° 56.32'	09:11:31	3°	246°	31km
139° 15.0'	29° 41.02'	29° 59.23'	29° 50.09'	09:11:33	3°	246°	30km
139° 30.0'	29° 34.87'	29° 52.91'	29° 43.85'	09:11:34	3°	246°	30km
139° 45.0'	29° 28.70'	29° 46.58'	29° 37.60'	09:11:36	3°	246°	30km
140° 00.0'	29° 22.53'	29° 40.23'	29° 31.35'	09:11:37	2°	246°	30km
140° 15.0'	29° 16.35'	29° 33.89'	29° 25.09'	09:11:38	2°	246°	29km
140° 30.0'	29° 10.17'	29° 27.53'	29° 18.82'	09:11:39	2°	245°	29km
140° 45.0'	29° 03.98'	29° 21.17'	29° 12.54'	09:11:40	2°	245°	29km
141° 00.0'	28° 57.78'	29° 14.80'	29° 06.26'	09:11:41	1°	245°	28km
141° 15.0'	28° 51.57'	29° 08.42'	28° 59.96'	09:11:41	1°	245°	28km
141° 30.0'	28° 45.36'	29° 02.04'	28° 53.67'	09:11:42	1°	245°	28km

TOTAL SOLAR ECLIPSE EXPOSURE GUIDE

FOCAL RATIO											ISO FILM SPEED				
2	2.8	4	5.6	8	11	16	22	32	45	64	32	64	100	200	400
											16	8	4	2	1
											8	4	2	1	1/2
											4	2	1	1/2	1/4
											2	1	1/2	1/4	1/8
											1	1/2	1/4	1/8	1/15
											1/2	1/4	1/8	1/15	1/30
											1/4	1/8	1/15	1/30	1/60
											1/8	1/15	1/30	1/60	1/125
											1/15	1/30	1/60	1/125	1/250
											1/30	1/60	1/125	1/250	1/500
											1/60	1/125	1/250	1/500	1/1000
											1/125	1/250	1/500	1/1000	1/2000

FIGURE 3. Select the focal ratio that nearest matches your camera/telephoto/telescope combination from the grey section of the guide. Draw a vertical line until it meets a diagonal line that represents the part of the eclipse to be photographed. Then follow the horizontal line at the intersection point to the blue section to determine the exposure required with various speed films.

GETTING STARTED

If you are a beginner, this page is for you. If the tables of numbers in the back of this book seem a little daunting, forget them. You don't need them (yet). Nor do you need a telescope to discover the most spectacular show nature has to offer, the night sky. You just need this book to guide you along on your voyage of discovery of the Universe.

This page will concentrate on the first part of this book, the 'Monthly Sections', for this area has the most to offer the novice.

IS THIS USEFUL FOR WHERE I LIVE?

Although the information in Part I has been calculated for Sydney, NSW (latitude 33° 54'S, longitude 151° 15'E) it is useful for anywhere in eastern and central Australia (some of it is common for the world). The change in the appearance of the sky between cities and towns - even across a country as vast as Australia - is not large (see also 'Effect of Latitude' on the next page). The rise/set graphs are useful since they give an approximate local time of rising and setting - no matter where you live!

Times are given in Australian Eastern Standard Time (in Part I). No adjustment has been made for daylight saving time.

Part I is designed as a quick reference section for anyone who wants a summary of tonight's sky, without having to refer to lengthy, complicated tables. Precise data, like the exact rise/set time or position (RA and Declination) of the planets is in Part II.

SO WHAT CAN THIS BOOK HELP ME SEE?

The night sky regularly puts on displays for us called conjunctions. Since the planets, including Earth, are moving round the Sun, their positions change constantly with respect to the background stars. As seen in the sky, the planets seem to pass by each other and bright stars. When a planet is near another, the Moon or a star, it's called a conjunction. When the Moon is included, it's a wonderful sight.

Conjunctions can be spectacular events. An example of a good conjunction this year is the one between Moon, Saturn and Aldebaran on March 20 (see Sky View p. 35). These celestial dwellers all lie within a 5 degree circle in the NW evening twilight sky. This is simply a chance alignment of these celestial bodies. They only look close together; in space they are still separated by enormous distances. When talking distances, beyond the Earth, it is difficult to use normal scales such as metres or kilometres because the numbers would be so large. Instead, let's use the time it takes for light to travel from these objects to get a feel of the true separations. At the time of this conjunction, the light from the Moon takes a little over 1 second to reach us, Saturn 78 minutes and Aldebaran 60 years. If you include the open star cluster, the Pleiades, we are out to 400 years. Distances in astronomy do challenge the imagination and, on the scale of the Milky Way, this cluster is just in our neighbourhood!

Conjunctions are fun to watch, free, and entertaining. The equipment needed to see conjunctions? You guessed it... nothing!

The best times to see conjunctions are shown in the Sky View diagrams (there are 5-6 such drawings for each month). Each Sky View shows you an area of the sky that contains a conjunction or another interesting feature. The horizon is shown at the bottom of most Sky Views along with any useful notes. At the top of each Sky View is the date you should look. Since the planets move fairly slowly in the sky, many conjunctions occur over a number of days. This means you can often see the planets and stars starting to take their 'places' days before, and then drift apart for days after the event. The Moon is the only exception. It moves quite a bit each day against the background stars. This is why the Moon's position for more than one day is often shown on the same diagram. All the planets visible in a Sky View are labelled, as are the brighter stars.

To use a Sky View, simply go outside under the night sky at the time given and face the direction shown on the Sky View. What

you see in the Sky View will be a temporary map of the sky in front of you. Incidentally, if you don't know the directions around your house, use a street directory to show you which way is north.

There is more to the night sky than conjunctions. There are meteor showers, comets, minor planets (asteroids) and constellations. Not to mention the fascinating movements of the planets as they wander against the background stars. All are described in Part I.

Part I is divided into months. At the beginning of each monthly section is a curious looking graph called a rise/set chart. This series of squiggly lines is your guide to knowing when the planets, Sun and Moon rise and set. To use the chart, simply look at the current date on the bottom of the chart and follow that line upward until it intersects the object of interest. The rise or set time of the object can now be read on the left-hand edge of the chart. For example, on January 18, the Moon and Mars set together just after 10pm. Incidentally, when you see objects rising or setting together, look for a Sky View on that date. There is a Sky View for this conjunction (see p. 27)

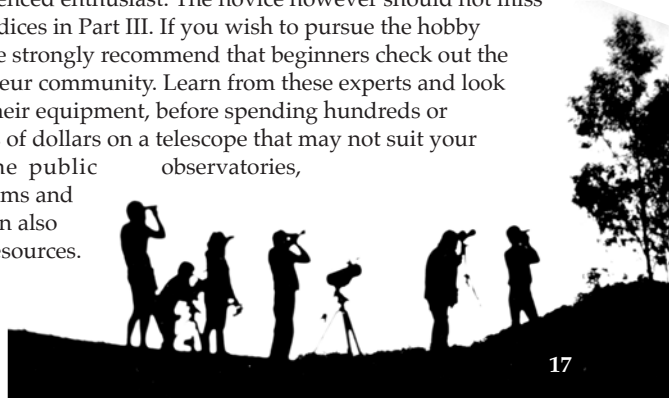
Each of these monthly sections also has diagrams showing the relative size and appearance of each planet, as seen through a telescope. There is also a description of celestial happenings and highlights - kind of like a celestial moviegoer's guide - and in plain English! Want to know what Venus is up to in March? The description will tell you. A diary of events is also included that summarises the month's features. To see some of these celestial events, you'll need a pair of binoculars or a telescope.

There is one piece of equipment that every sky watcher should have - a red tinted torch. Any torch will do. Simply tape some red cellophane over the end of the torch so that it gives off a dull red glow (see p. 33). The aim is to preserve your night vision, or 'dark adaptation'. When your eyes become used to the dark, they won't react to a red light and so you can use the charts and illustrations and still enjoy the night sky.

While on the subject of lights, make sure as many lights as possible near your observing site are turned off. The less glare around you, the easier it will be to enjoy the night sky. Encourage neighbours to turn off their outside lights and invite them to enjoy the night sky as well. A major modern threat to the night sky is light pollution; stray light scatters upward into the night sky where it drowns out the stars. So, the more lights we all turn off, the less light pollution, the more power we save and the less natural resources we consume. Perhaps it is time the environmentalists had a look at this. After all, it is the only form of pollution that costs less to fix!

The Sky Views don't show all the sky. By their very nature they mostly concentrate on the ecliptic or zodiac regions of the sky, where the planets and Moon wander. A good companion to this publication would be a basic star atlas or a planisphere. These will show all of the sky, but not the Sun, Moon and planets because they move. The planisphere is useful by showing at a glance all of the constellations visible at the time you are observing. An example is shown on page 8. Once you start to look around the sky with a planisphere, you may be pleasantly surprised how easy it is to recognise a few of the constellations. These star patterns will quickly become familiar and will soon be like old friends.

Part II of Astronomy 2002 contains specialised data designed for the experienced enthusiast. The novice however should not miss the appendices in Part III. If you wish to pursue the hobby further, we strongly recommend that beginners check out the local amateur community. Learn from these experts and look through their equipment, before spending hundreds or thousands of dollars on a telescope that may not suit your needs. The public observatories, planetariums and courses can also be great resources. Use them.



A WORD ABOUT BINOCULARS

Probably the most cost-effective accessory for the beginner are binoculars. Good quality binoculars can be purchased at the same cost as a cheap, low quality telescope. Binoculars can also be useful for Mum and Dad, especially if their budding junior astronomer loses interest. They can at least be used for more terrestrial pursuits. Such an investment can be a cheap way of gauging their level of dedication. This does not mean the authors are suggesting the quality of the binoculars should be poor. It is recommended that even binoculars should be purchased from a reputable optics or telescope dealer. They are people who appreciate the quality required for stargazing. Astronomy is indeed a severe test on optics. Such shops can also assist with mounts to hold the binoculars steady. These are often brackets designed to attach to a tripod (sorry, another possible expense). To observe details on the Moon or look for Jupiter's moons, it is recommended that binoculars are not hand held. Sometimes you can brace yourself on the arms of a chair or the roof of a car. This can be important if the power of the binoculars is more than 10X. A power of 7X is considered a reasonable compromise. It can give a good field of view with adequate magnification to glimpse some of the moons of Jupiter. The size of the aperture normally comes down to what is comfortable for the person to hand hold and the budget. 7X50 binoculars (7 times magnification, 50mm diameter front lens) are fairly popular with amateurs.

There are a multitude of uses for binoculars in amateur astronomy. Some of these include:

- Helping to find stars and planets in the bright twilight sky.
- Looking at the craters and rays on the Moon.
- Looking for fainter stars marked in star atlases or on the Sky Views and finder charts in this publication. This can be important in bright, light polluted skies.
- Looking for stars dimmed by the nearby Moon.
- The colours of the stars and planets are more obvious through binoculars. Check out the red colour of Mars, Aldebaran, Betelgeuse and Antares. Also, the contrast between the yellow of Alpha Centauri and the blue of Beta Centauri is interesting.
- The crescent phases of Venus.
- Stars and planets close to the horizon.
- Looking for artificial satellites in the early evening sky.
- Monitoring the change in magnitude of some of the brighter variable stars (see the 'Mira' example on p. 53). There are also a number of organisations that can help with finder charts and predictions. Start with your local astronomical society.
- Observing the moons of Jupiter as they oscillate across the planet from night to night (see the diagrams on pages 107-109). It is also possible to observe an occasional eclipse disappearance or reappearance for one of the outer satellites (pp. 105-106) as the moon passes into or out of the shadow of the planet.
- Lunar occultations of some of the brighter stars (see also Part II). Small binoculars are well suited for magnitude 4 or brighter events, preferably on a dark limb. There is no reason why one should not time the event as described on page 89.
- Looking for bright comets (from dark skies).
- Some of the bright deep sky objects such as the star clusters, Milky Way regions and the Magellanic Clouds.
- Looking for some of the brighter minor planets near opposition. A good exercise is to sketch the field a couple of times a few days apart and see which 'star' has moved.
- Searching out Uranus and Neptune, see finder charts, p. 118.

Most of the above can be done from a typical suburban backyard. It is not necessary to drive for an hour to reach dark skies. Also scanning the skies for satellites can open up a whole new Universe of discovery as various star clusters and nebulae drift through your field of view.

Finally, it is worth remembering that a pair of binoculars is prone to dewing just like a refracting telescope. A couple of cardboard tubes on the front, sticking out about 75mm, can prevent dew and also help eliminate stray light.

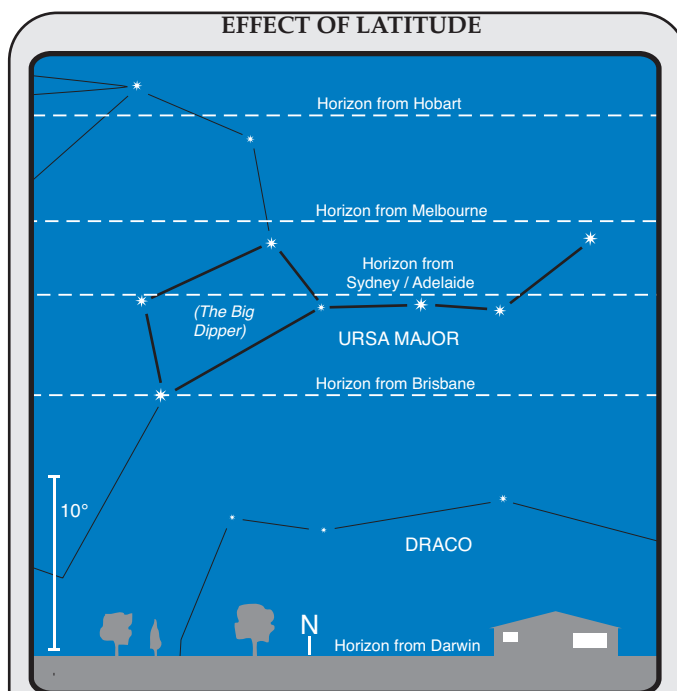
SOME ASTRONOMICAL TERMS TO GET YOU STARTED

There are several astronomical terms you'll come across in Astronomy 2002, many of which are defined in the glossary at the end of the book. Here are a few of the more common ones, just to get you started.

Planet. Just like the Earth! A planet is a sphere of either rock or gas that orbits the Sun or another star. There are nine planets in our Solar System, and the Earth is the third planet out from the Sun. The diagram on page 79 gives a good overview. There are also a number (actually tens of thousands) of 'minor planets' that move around the Sun, mostly between the orbits of Mars and Jupiter. The Moon and all the planets we see in the sky do not glow in their own right. They are only visible because of reflected sunlight.

Star. Just like the Sun. A star is an enormous sphere of glowing gas that gives off tremendous amounts of light and heat. They shine by their own light caused by nuclear reactions going on deep inside them. It's a testament to the enormous distances between the stars when you realise that the Sun is a relatively average star, while some stars visible in the night sky are tens or hundreds of times larger and brighter, yet in our sky look so faint.

Time. The times used in Part I are in Australian Eastern Standard Time (AEST). AEST is the mean solar time on the meridian of longitude of 150°E. For Australian Central Standard Time (ACST) subtract 30 minutes from the times given. For other time zones make the appropriate adjustments. No allowance has been made in



The Sky Views (see the monthly sections) have been drawn for a latitude of approximately 33° south of the equator. This is reasonably central for the population distribution of Australia. However, we live in a large continent which covers a wide range of latitude. The further one goes north the more stars we see familiar to our northern hemisphere friends. As an example, let's take the 'Big Dipper'. You may have first heard about this in books written in say England or America. This group of stars is part of a larger group known as the constellation Ursa Major, the Great Bear. From Darwin the group is clearly visible above the horizon (but upside down). However, from the southern states not all of it is visible. The Big Dipper is best placed in the northern sky in mid-May around 9pm (mid-June, 7pm). Also from the south we see very little of the constellation Draco. The diagram (above) is drawn to the same scale as a Sky View.

this book for Daylight Saving, also known as 'Summer Time'. When daylight saving is in force, the time is one hour ahead of AEST. For example, any rise/set time for an object in this book will need to have one hour added to it to get daylight saving time.

Magnitude. The brightness of an object in the sky is known as its magnitude (sometimes abbreviated to 'mag.'). The numbers work backwards. The faintest star you're likely to see with the naked eye is about 6.0 magnitude (under country skies), while the brightest stars are -1.0 magnitude. Planets can be much brighter. Venus, for example, can be as bright as -4.0 magnitude, the Full Moon, -12 magnitude!

Angles in the sky are measured in degrees. You'll see that the 'Sky Views' have a line showing what an angle of 10° looks like on the scale of these drawings. On the back cover is a scale that can help you measure angles. It is an interesting exercise to go out on nights when there are conjunctions and do your own measurements of the objects' separations and compare your results with the predictions in this book.

Twilight does not really end until the Sun is 18 degrees below the horizon; this is called 'astronomical twilight'. This happens about 90 minutes after sunset (or before sunrise) and is different from what people would normally call the end of twilight. This would be civil twilight, which begins or ends when the Sun is 6° below the horizon (about 30 minutes before sunrise or after sunset). Only when astronomical twilight has ended, is the sky considered truly dark (assuming the Moon isn't above the horizon!). But keep in mind that many celestial features can be seen even during twilight; binoculars can also help. The actual time between sunset and end of twilight (and the beginning of dawn and sunrise) does vary with latitude. The further south, the longer the time of twilight. Compare the times of twilights and rise/sets in Part II between Darwin and Hobart.

Culmination. When an object culminates it has reached its highest point in the sky and is generally considered to be the best time to observe it (assuming it's night). For the planets, this is normally when they are due north.

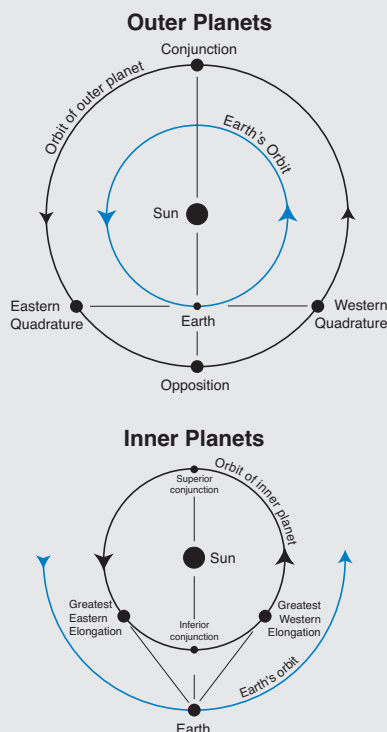
HOW DO I USE THIS BOOK TO PLAN MY OBSERVING?

This publication was never intended to be read from cover to cover (but we don't mind if you do!). It is a reference work, which, if you look closely enough, gives you a number of pieces of the picture. Also, the picture is quite different depending on whether you are using your eyes, binoculars, or a telescope. The data that an astrophotographer would find useful could again differ. To illustrate how to use the book we will work through an example.

You are planning to go out and observe on the evening of June 14 (for once the weather is looking OK). A good place to start is the 'Visibility of the Planets' chart (p. 23). Looking around mid June, the diagram is showing Mars, Jupiter, Venus and Pluto in the evening sky, with Mercury, Uranus and Neptune in the morning. A quick check of the 'Rise/Set Chart' for June (p. 44) certainly shows Mars, Jupiter and Venus setting in the early evening sky. Venus and the Moon are setting close together which would indicate a conjunction and there may be a sky view for this date. On p. 47 there is indeed a sky view, 'Jun. 12 to 15' showing not only Venus with the Moon but also Mars and Jupiter in the early evening twilight sky. Venus is rising in the evening sky, heading towards its greatest eastern elongation in August. Although Venus currently shows only a small gibbous disk of around 13 arc seconds (see 'Appearance of the Planets' diagram p. 44) it is also heading towards inferior conjunction in October so its size will grow. Although Jupiter is quite low in the twilight, there is a satellite event visible on this evening (see section starting p. 104). At 5.55pm the moon Io will finish (egress) its transit across Jupiter's disk, which will be followed by its shadow at 6.31pm.

With the Moon setting early in the evening (8pm) there is little opportunity to spot any occultations of stars by our satellite during that night. It is better to wait until the Moon spends more time in the night sky. For example on June 18 there is an occultation of 5th

ORBITAL ASPECTS



A **conjunction** of a planet and the Sun is when they are closest together in the sky (not the best time to observe the planet). When an inner planet is between us and the Sun it is said to be at inferior conjunction, when on the far side of the Sun we have a superior conjunction. It is also common to hear this word referring to any two or more objects when they are closest to each other in the sky, that is their minimum angular separation.

Opposition refers to the time a planet is opposite the Sun in the sky. An object in opposition will rise around sunset and will be visible the entire night (like the Full Moon). The inner planets, Mercury and Venus, can never reach opposition. Their orbits

are both inside Earth's. We need to pass between an object and the Sun for opposition to occur.

Elongation is often used in reference to the inner planets and their greatest angular distance from the Sun, that is greatest western elongation (in the eastern morning sky just before sunrise) and eastern elongation (a western evening sky object just after sunset). This is generally the best time to observe Mercury and Venus.

magnitude star ZC1773. There is a dark limb disappearance for most of Australia (e.g., Canberra sees the event at 11.12pm, see p. 92). The Moon misses the star from Melbourne and Hobart.

Back to the evening of June 14, a look at the 'Diary' for June (p. 46) indicates that the minor planet 654 Zelinda makes a close approach to the spiral galaxy NGC 2974 in Sextans this evening. The minor planet section (p. 121) has the magnitude of Zelinda at around 12.7, so it is not an object for a small telescope. A check with a planisphere (see example p. 8) tells us this constellation sets around 10pm this evening so one should get onto this event as early as possible. This conjunction may attract the astrophotographer wishing to catch a minor planet next to a deep sky object. While we are talking faint objects, the comet C/2000 WM1 (LINEAR), at magnitude 12, is in the constellation of Hercules making a close approach to the globular cluster M13 on the 18th (refer comet text and diary p. 46).

For those wishing to chase our most distant and faint planet Pluto, it is rising at sunset and hence is visible the entire night. You will need at least a 20cm telescope and the finder charts on pp. 118, 119 to find this world (not an exercise for the beginner).

Both Uranus and Neptune rise during the evening. It is always a good idea to wait a couple of hours, when possible, so the planet is higher and you are not looking through a lot of atmosphere. Therefore an early morning timeframe may be best to observe these distant bodies (as per the 'Visibility' recommendations on p. 23). Finder charts for these planets are located on p. 118.

For those looking for an 'all nighter', let's look at the next morning (15th). Mercury is reasonably placed, rising just before the start of dawn. (See Rise/Set, p. 44 and the 'Movement of the Planets' diagram, 'DAWN SKY - Jun. To Sep. 2002' on p. 22). Through even a small telescope it will show a thin crescent as shown in the

‘Appearance’ diagram on p. 44. Unfortunately, Saturn has just gone through conjunction with the Sun, moving into the morning sky but is still too close to the Sun to observe its spectacular rings. It is probably best to wait until July for Saturn when it will be rising before dawn.

This is an example of the way to apply the information within this book and how it can be a lot of fun planning an observing session.

THE MONTHLY SECTIONS

Each monthly chapter in Part I contains the following:

RISE/SET CHART

This will enable the reader to quickly determine when (or if) a planet or the Moon is visible in the night sky for any day in that month. Each chart has the midnight line centred, with the evening sky below this line and the morning sky above. The two bands of ‘lighter’ shading show the times of morning and evening astronomical twilight. If you are using a telescope you’ll soon learn to avoid trying to observe a planet near the horizon (close to rise or set times). Turbulence in the much thicker atmosphere (at low altitude) gives very poor ‘boiling’ images. If more accurate rise/set times are required, you will need to refer to the specific tables for the object of interest in Part II of this publication. You can also adjust for rural locations using the appendix on page 130.

APPEARANCE OF THE PLANETS

This diagram provides the reader with a telescopic view of each planet drawn to the same scale. Under each image is the date, the planet’s angular diameter and magnitude. Phases are also shown for Mercury, Venus and Mars. Each planet is presented with the north pole to the top.

MONTHLY HIGHLIGHTS

This lists a few of the more interesting events during the month.

THE MOON

This provides information on any events relating to the Moon. The data includes the Moon’s phases, apogee, perigee, occultations of planets or bright stars and lunar and solar eclipses. The event does not have to be visible from Australia to be included. The description will normally indicate whether or not it can be seen. Throughout the monthly section the Earth–Moon distance quoted is between the centres of the two bodies.

There will be no occultations of bright stars by the Moon during 2002, the next bright star occultation will be in January 2005 when the 1st magnitude star Antares passes behind the lunar limb. There will be 19 planet and major asteroid occultations this year (somewhere in the world) plus the usual multitude of fainter star events (see also Lunar Occultations in Part II for details).

THE PLANETS

Presented are general notes on each planet. Emphasis is placed on their suitability for observation and any interesting conjunctions and patterns between the Moon, other planets and bright stars.

MINOR PLANETS (or Asteroids)

This section deals with the 20 brightest asteroids that reach opposition this year. An entry is included if the asteroid reaches opposition during that month, when it is brightest. It lists the magnitude and constellation the asteroid is in at the time of opposition.

COMETS

This section deals with the comets expected to be visible during the year. It points out those that are observable during the month and includes any interesting conjunctions. Note, most of the known comets this year are relatively faint and will need a telescope.

It is likely that many other comets will be discovered during the year. We have seen some spectacular ones in recent years, including Comet C/2001 A2 (LINEAR) (see p. 41). Let’s hope the trend continues this year.

METEOR SHOWERS

On any clear night we can sometimes see up to five shooting stars per hour, these are known as random or sporadic meteors. There are also annual ‘showers’ which return at the same time each year. Each shower seems to radiate from a focal point in the sky and is named after the constellation or a bright star the radiant lies near. For example, the radiant for the Leonids lies within the constellation of Leo. The monthly section lists the major showers for this year that are suitable for observation. These selected showers are those largely unaffected by moonlight during their peak period. More details for all showers are given in Part II. It takes great patience to watch for meteors but the occasional fireball makes it all worthwhile. It is best to do your searching on moonless nights, away from light polluted cities. As a general rule, more meteors are seen after midnight.

DIARY OF EVENTS

This is a list of all general phenomena associated with the planets and Moon. The presentation is keyed to those people who would like to know ‘what’s happening tonight (astronomically speaking)?’ Included are:

- Phase of the Moon.
- Key events in a planet’s orbit.
- Selected conjunctions between the Sun, Moon, comets, minor planets (asteroids), brighter stars and deep sky objects (see also page 129 for descriptions of some of the brighter non stellar objects).

Conjunctions. Differences will be often found between the separation distances (and times quoted) and those found in the remainder of Part I. Conjunctions involving only the bright stars, the planets and the Moon are geocentric. This is how they would look from a position corresponding to the centre of the Earth. The exact time of closest approach may be in daylight from Australia, or the objects of interest may not be above the horizon for us. The planetary text and Sky Views have been tailor made to suit Australia. Hence the times and angles given in the Diary of Events could differ from those on a Sky View. Sometimes a lunar conjunction is followed by ‘occultation’. This indicates that from somewhere in the world, the object will be occulted (covered) by the Moon. The distance given is measured from the centre of the Moon (remember, the Moon has a diameter of 0.5°). Occultations involving the planets or the brightest stars are also mentioned in the ‘Moon’ text.

Abbreviations. These include:

- G which is for a galaxy (SG - spiral, IG - irregular, EG - elliptical).
- OC represents an open cluster
- GC is a globular cluster
- PN is a planetary nebula
- m.p. equals a minor planet

There are also some astronomical catalogues including:

- NGC – New General Catalogue
- IC – Index Catalogue
- M – Messier catalogue.

FEATURE ARTICLE

This section concentrates on some topics in popular astronomy. This can include observational, historical, profiles of astronomy enthusiasts, astronomical equipment and techniques.

SKY VIEWS

These diagrams are designed to help you find the planets. The date and time of each diagram has been carefully chosen to show the most interesting patterns of the planets and Moon. Sometimes the times chosen correspond to about one hour (or even down to 30 minutes) before sunrise or after sunset. Although, astronomically speaking, this would still be considered twilight, this is sometimes necessary to catch a glimpse of the planets when they are close to the Sun. This is especially needed for Mercury, because it never wanders more than 28° from the Sun. Sky Views which show a twilight view after sunset are called ‘Evening Twilight’ and morning twilights are ‘Dawn Sky’. Those before midnight are

'Evening Sky' and after midnight, 'Morning Sky'.

The 'Sky Views' (see also the legend below) include:

- The Moon (showing approximate phase) and the planets visible with the naked eye.
- All stars down to about 4.5 magnitude.
- Names of the brightest stars.
- Bright star clusters, nebulae and galaxies (down to approximately 5.5 magnitude). These objects are named using the following codes. A prefix of 'N' means the object is in the New General Catalogue (NGC), an 'I' is the Index Catalogue (IC) and 'M' is a number in the Messier catalogue. Many of these deep sky objects are also listed on page 129 in 'Non Stellar Objects'.
- Constellations are labelled (capital letters) and have black lines joining key stars.

When using these 'windows to the sky' it is important to keep in mind that the horizon shown is theoretical, like looking out over the ocean. You will soon learn to make mental adjustments for local hills, trees and buildings etc. The scale has been kept constant and a 10° reference bar is marked. Sometimes the object of interest is so high, the field of view is not large enough to include the horizon.

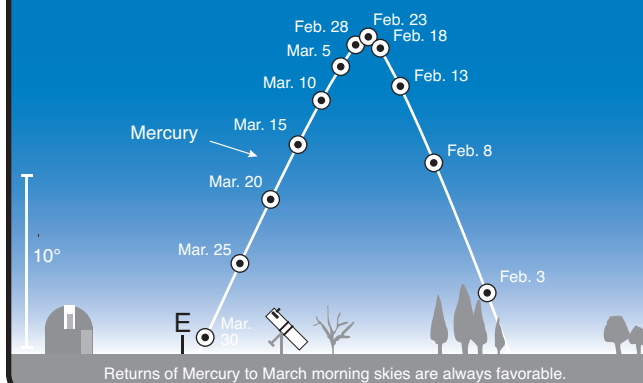
The Sky Views are useful for more than just the date and time shown. The pattern of stars relative to the horizon will appear the same one month later, but 2 hours earlier. Of course the planets and the Moon will have moved. Compare the Sky Views for Aug. 4 to 6 (5am) with Aug. 31 to Sep. 2 (3am), see page 55. A few minutes playing with a planisphere (p. 8) will also show this yearly motion of the stars.

Uranus, Neptune and Pluto have been excluded from the Sky Views as they are not generally visible to the naked eye. To see Uranus you would certainly need dark sky conditions. Neptune will need binoculars, while Pluto will need at least a 20cm telescope to glimpse this faint member of our Solar System. In any case, because of the many faint stars of similar brightness close by, finder charts would be needed to identify these outer worlds. Charts for these planets are on pages 118-119.

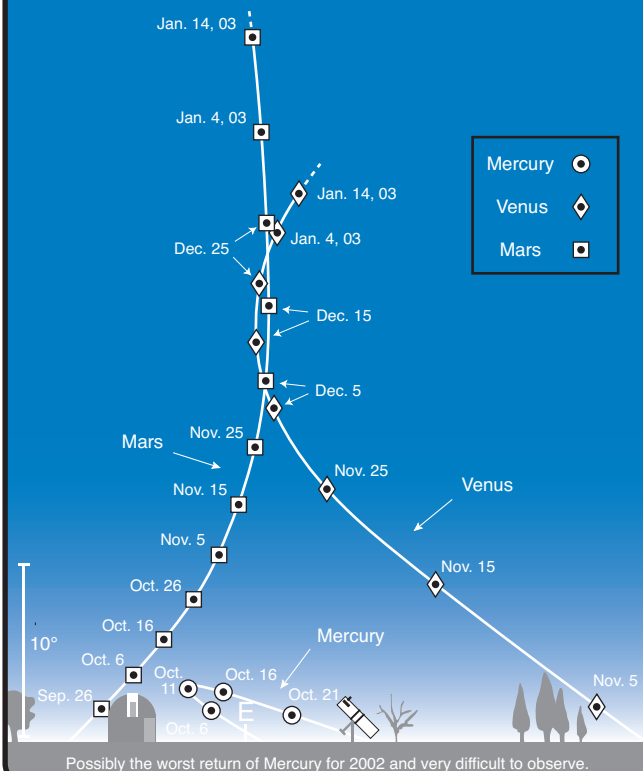
MOVEMENT OF THE PLANETS

These diagrams are designed to help observers know when the planets first become observable after being in conjunction with the Sun, or when they are about to go into conjunction with our star. The drawings are particularly useful as an observing guide for Mercury. In addition, the Visibility of the Planets diagram (p. 23), allows you to see at a glance whether an object is in the morning or evening sky.

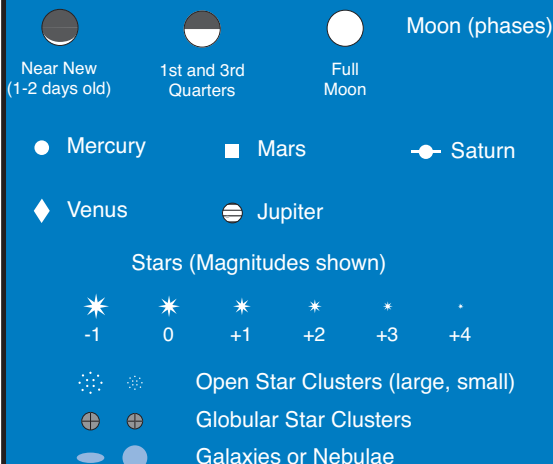
DAWN SKY- Feb. to Mar. 2002 (30 mins before sunrise)



DAWN SKY- Oct. to Dec. 2002 (30 mins before sunrise)

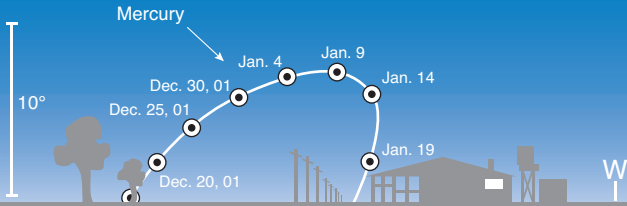


LEGEND FOR SKY VIEWS

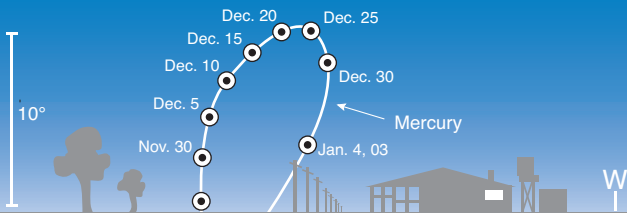


MOVEMENT OF THE PLANETS

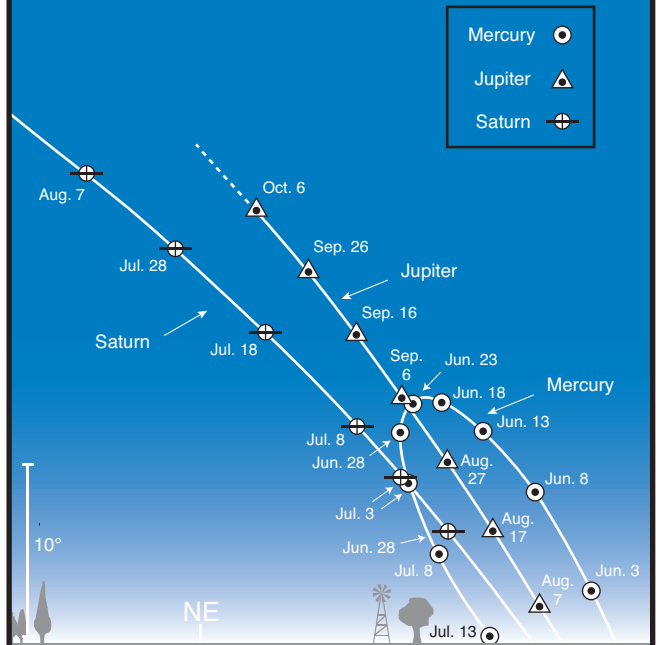
EVENING TWILIGHT - Dec. 01 - Jan. 02 (30 mins after sunset)



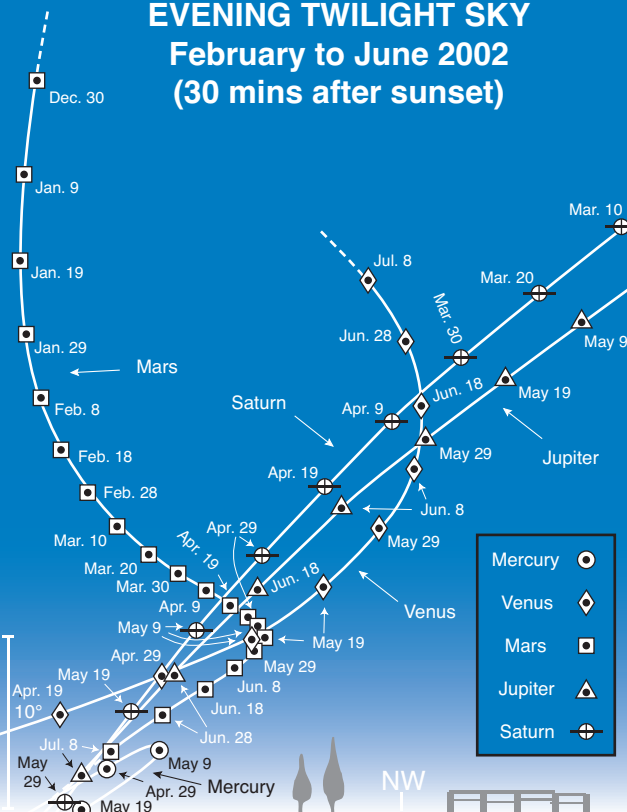
EVENING TWILIGHT - December 2002 (30 mins after sunset)



DAWN SKY- Jun. to Sep. 2002 (30 mins before sunrise)

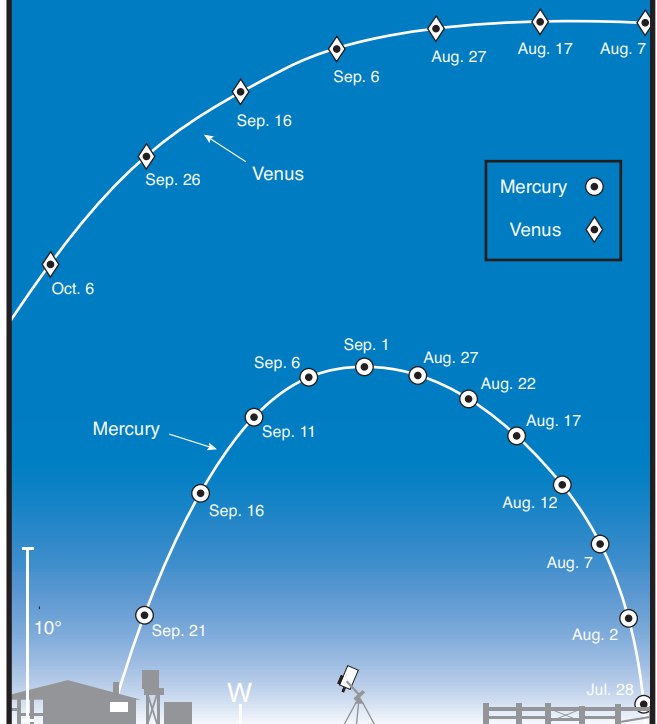


EVENING TWILIGHT SKY February to June 2002 (30 mins after sunset)



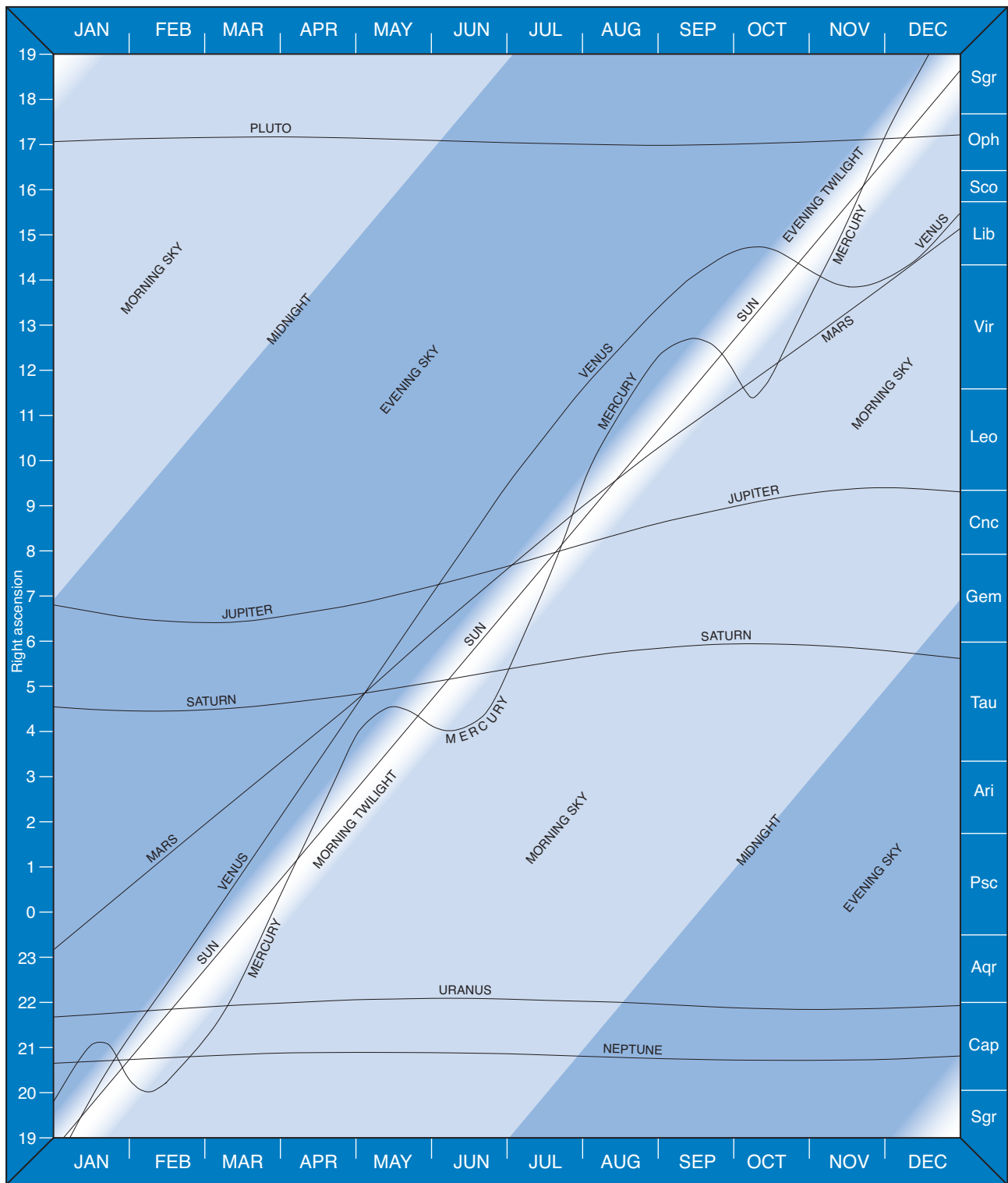
You will notice these 5 naked eye planets cluster together in the evening sky in late April / early May. See also the monthly sky views.

EVENING TWILIGHT - Aug. to Sep. 02 (30 mins after sunset)



Returns of Mercury to August / September evening skies are always favourable.

VISIBILITY OF THE PLANETS



This diagram plots the right ascension of the Sun and planets throughout the year. The light area on either side of the Sun line is that part of the night sky affected by twilight. From this relatively simple diagram a wealth of information can be determined. For example, find your date of observation along the bottom and look up the page until it intersects a planet line. This will show if it is best to view the planet in the morning or evening sky. From the intersection point a horizontal line to the right vertical axis will show which constellation the planet is in (Jupiter, in the first half of the year, is visible in the evening sky in Gemini).

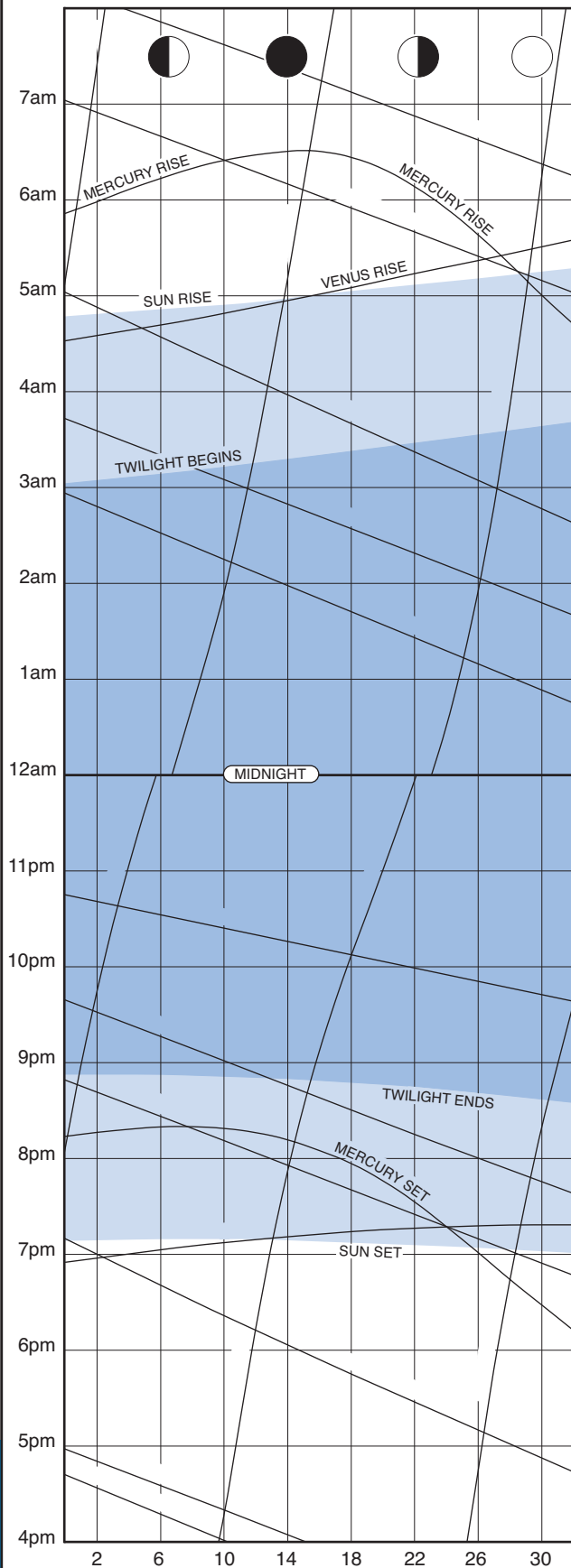
Mercury and Venus are in conjunction when they cross the Sun line and at their greatest elongation when furthest from it. The best

times to observe Mercury are from mid-February to mid-March for the morning sky, and from mid-August to mid-September in the evening, when its path extends beyond twilight. When an outer planet crosses the midnight line, it is at opposition and is visible the entire night. Where an outer planet's line shows a downward slope, it is in retrograde motion.

The diagram also shows when conjunctions between the planets occur. When two or more lines cross, the planets will be close together in the sky. This year's conjunction between Venus, Mars and Saturn is clearly shown where their paths cross in the early May evening sky.

JANUARY

RISE/SET CHART



All times are AEST. For daylight saving time add 1 hour.

JANUARY HIGHLIGHTS

- Mercury and Neptune close in the evening sky
- Mercury and crescent Moon close in evening twilight
- Jupiter at opposition
- Saturn near Aldebaran

THE MOON

- 2nd Moon at perigee (closest to Earth – 365,406 km distant, angular size 32.2')
- 6th Last Quarter
- 13th New Moon
- 18th Moon at apogee (furthest from Earth – 405,505 km distant, angular size 29.8')
- 22nd First Quarter
- 25th Occultation of Saturn by the Moon, visible from parts of Asia
- 27th Occultation of Jupiter by the Moon, visible from Northern Hemisphere
- 29th Full Moon
- 30th Moon at perigee (closest to Earth – 359,996 km distant, angular size 33.0')

THE PLANETS

SUN (under the heading of useless information) During 2002 the Barycentre (centre of gravity) of the Solar System will continue to be outside of the globe of the Sun (until July 2003).

APPEARANCE of the PLANETS

MERCURY

5th Jan
dia 5.84"
mag -1.8

Mercury is in inferior conjunction on the 28th

12th Jan
dia 6.86"
Gt Eastern
Elongation
mag -0.6

30th Jan
dia 10.22"
mag 2.3

VENUS



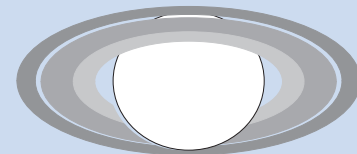
15th Jan
dia 9.75"
mag -3.9

Venus is in superior conjunction on the 14th

MARS

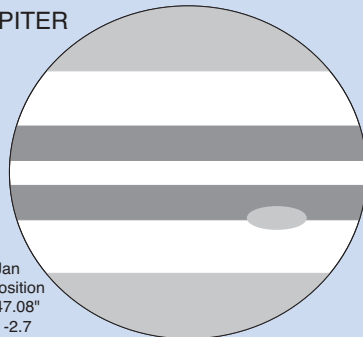
15th Jan
dia 5.85"
mag 0.9

SATURN



15th Jan
dia 19.90"
mag -0.2

JUPITER



1st Jan
Opposition
dia 47.08"
mag -2.7

URANUS

15th Jan
dia 3.38"
mag 5.9

NEPTUNE

15th Jan
dia 2.20"
mag 8.0

PLUTO

15th Jan
dia 0.11"
mag 13.9

MERCURY, for the first half of January, is located in the western evening twilight, setting about an hour after the Sun. The planet's greatest elongation east of the Sun (19°) occurs on the 12th, and then it races back toward the Sun and inferior conjunction (between Earth and Sun) on the 28th. Moving from Sagittarius into Capricornus early in the month, Mercury passes less than 0.5° from the globular cluster M75 (NGC6864). An encounter between the Sun's nearest planet and one of its most distant, Neptune, occurs on the 9th when the two are 1.3° apart. On the 15th, the very thin crescent 2-day old Moon appears 3.7° above the planet (see Sky View).

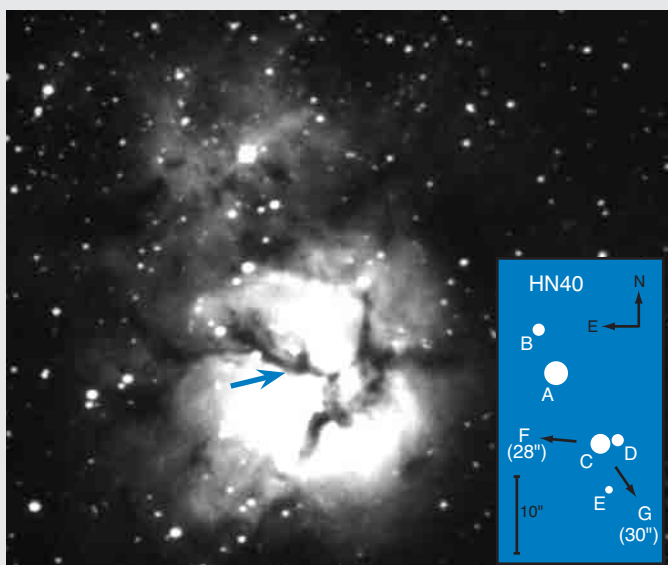
VENUS is too close to the Sun for observation this month. In superior conjunction on the 14th (Venus and Earth on opposite sides of the Sun), the planet remains near the Sun until its debut in the evening sky in late February.

The **EARTH** is at perihelion (the closest point in its orbit to the Sun) on the 2nd. The Earth/Sun distance is 0.98329 astronomical units, which is equivalent to about 147 million km.

MARS is visible in the western evening sky, setting around 10pm. After the June 2001 favourable opposition, the planet has now diminished substantially in size and brightness. For most of the year Mars will remain below 1st magnitude and present a disk size of less than 5 arc seconds. Hardly an exciting telescopic object. On the 18th, the 4-day old Moon will be 9° south of the planet, and on the following evening 5.2° above (see Sky View).

JUPITER begins the year in opposition, visible for the entire night in Gemini. Although the planet is a worthy telescopic object at any time of the year, opposition provides a good-sized disk that is around 50% larger than when near conjunction

MULTIPLE STARS IN WELL KNOWN NEBULAE



Multiple Star HN40 in the Trifid Nebula. Photograph by J. Cauchi

The casual observer, when looking at nebulae, tends to stay with low power eyepieces. It is worthwhile going to a higher power. Not only does this have the potential of increasing the contrast of the nebulosity, but it may also reveal some surprises in their central star systems (if present). Two famous examples are given here. With photographs of the Trifid and Orion nebulae, even short exposures with amateur equipment, the central stars will easily burn out. The positions of the multiple stars are arrowed. The photos and inserts are positioned with north to the top.

HN 40 and the Trifid Nebula. Tucked into the fork of the dark rifts in the Trifid lies the multiple star system HN40 (the three dark rifts form the 'trifid' pattern). HN40 is thought to be the chief source of illumination for the Trifid, but there may be many hot stars hidden from view. The main three stars are easily visible in a small telescope, with 'D' presenting no real problems. It took S. W. Burnham, using the 36 inch Lick refractor, to detect the fainter components. Perhaps an interesting challenge for those large aperture scopes, fairly common with amateurs these days?



Trapezium in Orion Nebula. Photograph by J. Cauchi.

The Trapezium in the Orion Nebula. The Orion nebula is fluorescing due to the strong ultraviolet radiation from the Trapezium. These stars are likely to be a central core of a compact cluster of much fainter stars. The Trapezium is probably the best known multiple star system but many observers may only know of its four main components. The E star shouldn't be a problem in small instruments with F being a little more difficult. The G star is a real challenge considering it took the 36 inch refractor at Lick Observatory to detect it (A.G. Clark was the discoverer in 1888). While we are talking about tests, H has been shown to be a pair of 16th magnitude stars, separated by $1.3''$. Stars A and B have been found to be variable, both being eclipsing binary stars. 'A' was found in 1975 to have a period of 65 days with a range of 6.7 to 7.7 magnitude.

Component	A	B	C	D	E	F	G	H
HN40	7.4	10.5	8.5	10.5	12.4	13.8	13.2	-
Trapezium	6.8	7.9	5.4	6.8	11.1	11.5	16.7	15.8

HN40 and Trapezium Magnitude Table

JANUARY

(compare the planet appearance diagrams for January and July). On the 26th, the 12-day old Moon appears 4.8° north of Jupiter and on the following evening 9° to the south (see Sky View). As a matter of interest, on the 1st January (the date of opposition) any Jovian residents looking sunwards will witness a transit of the Earth and the Moon across the face of the Sun. The next such transit occurs during the opposition of July 2008.

SATURN, in Taurus, remains within 4° of the 1st magnitude star Aldebaran throughout the month. Just one month past opposition, the planet makes a good telescopic target high in the mid-evening northern sky. On the 24th, the 10-day old Moon appears 2.7° from Saturn (see Sky View).

URANUS and **NEPTUNE** in Capricornus, both setting in evening twilight, will reappear late February in the morning sky. Neptune will be in conjunction with the Sun on the 29th. This is the 3rd in a series of eight annual Neptunian conjunctions, where the planet is occulted by the Sun's disk (not observable). The next series begins in the year 2080.

PLUTO rises in the morning sky in Ophiuchus. The slow moving planet will remain in this constellation until February 2003 when it moves into neighbouring Serpens.

MINOR PLANETS at opposition this month include 9 Metis on the 13th at magnitude 8.7 in Gemini and 654 Zelinda on the 10th at magnitude 9.8 in Gemini.

COMETS

Comet 19P/Borrelly is low in the pre-dawn sky during January. The comet should fade from 12th to 13th magnitude as it sinks closer to the northern horizon, spending the entire month in the constellation of Canes Venatici. During the first week of January, Borrelly is about two degrees from 4th magnitude Beta Canum Venaticorum. On 7th January, the comet is a degree away from the 9th magnitude galaxy M94.

Comet C/2000 WM1 (LINEAR) should open the year at 6th magnitude in the evening sky, low in the southwest at the end of twilight. Moving quickly from Grus into Indus, and then into Telescopium, the comet will fade after perihelion on 22nd January at 0.6 AU from the Sun. By month's end, when LINEAR could be 7th magnitude, it is best observed in the southeast morning sky.

METEOR SHOWERS

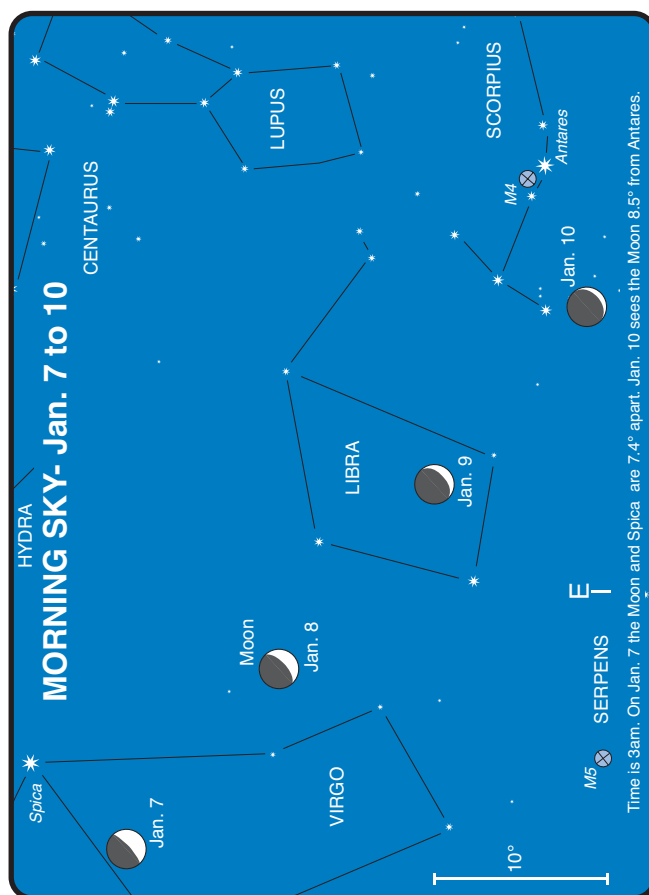
The **delta-Cancrids** are a minor meteor shower, with the radiant in Cancer above the horizon for most of the night. Typically faint, the zenith hourly rate is unlikely to rise above 3 to 5. The showers' duration is from the 1st to 24th. January 17th will be their maximum.

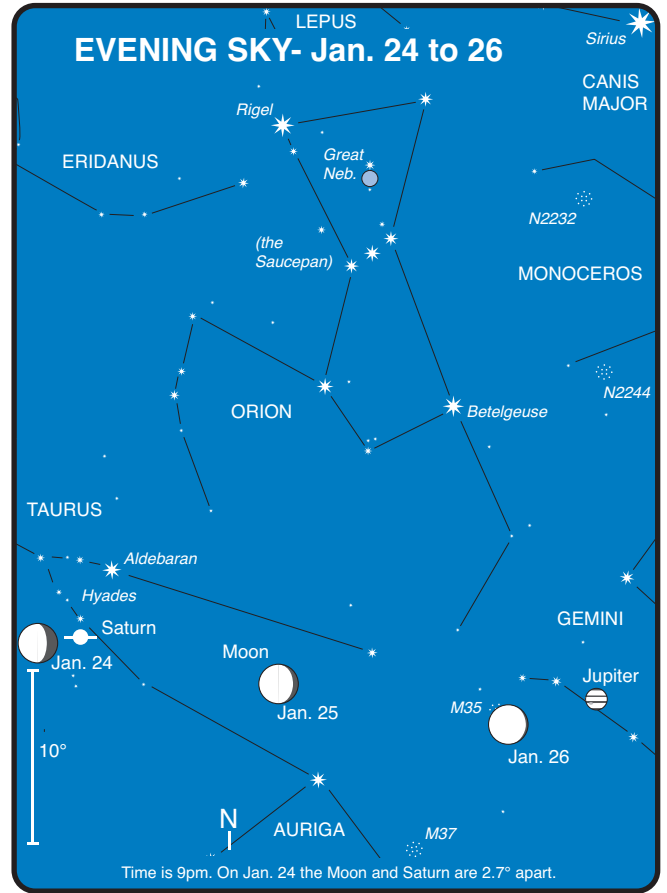
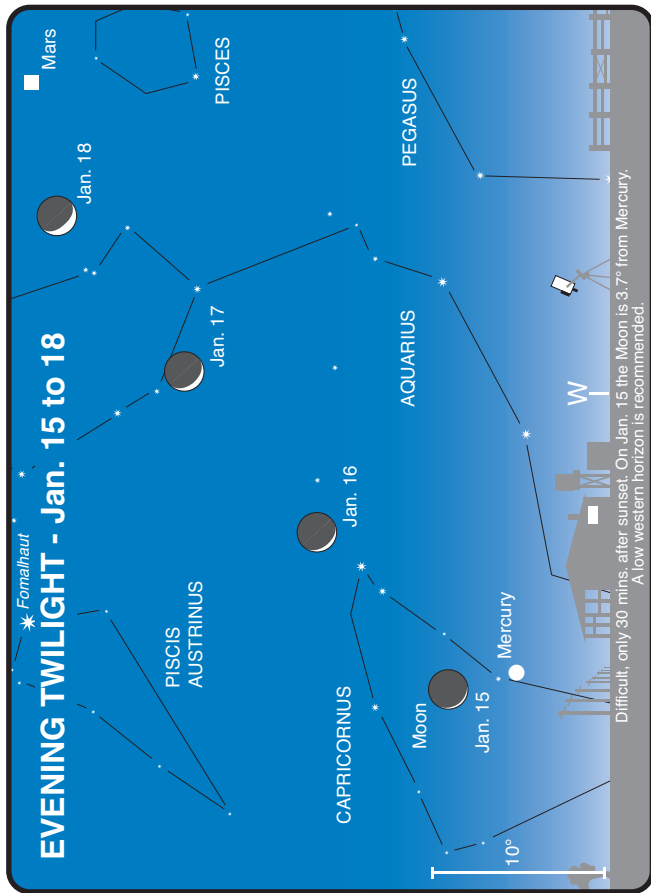
DIARY

1st		m.p. 6 Hebe 0.1° W of star Zeta Ophiuchi
1st	4 PM	Jupiter at opposition
2nd	5 PM	Moon at perigee
2nd	Midnight	Earth at perihelion
3rd		Mercury 0.4° SE of M75 (GC) in Sagittarius
6th	1:55 PM	Last Quarter Moon
7th		Uranus 0.5° N of m.p. 44 Nysa
7th	9 PM	Comet C/2000 WM1 (LINEAR) 0.3° NW of NGC 7090 (SG) in Indus
9th	8 AM	Pallas in conjunction with Sun
9th	3 PM	Mercury 1.3° S of Neptune
9th	11 PM	m.p. 654 Zelinda 0.4° NW of NGC 2395 (OC) in Gemini

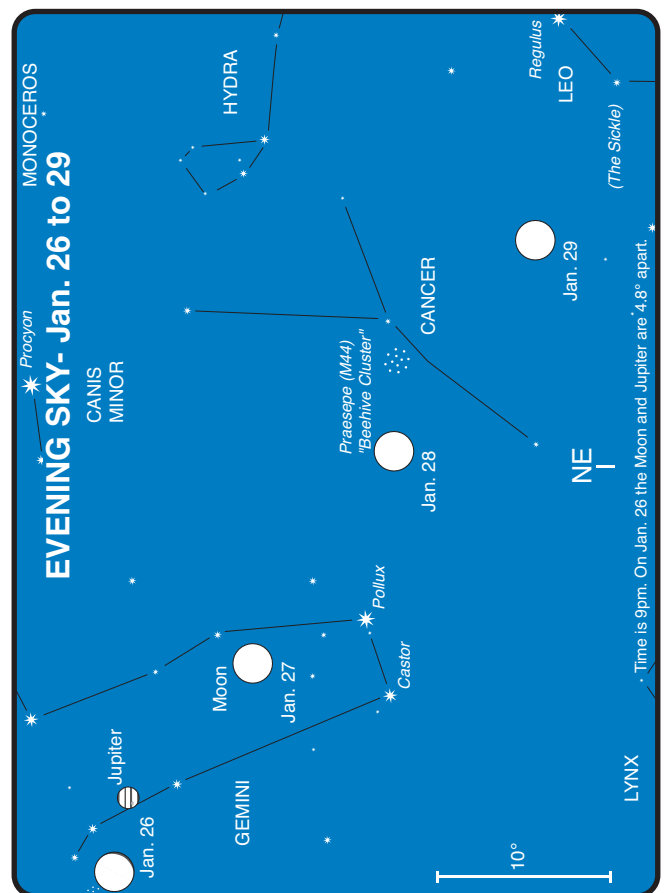
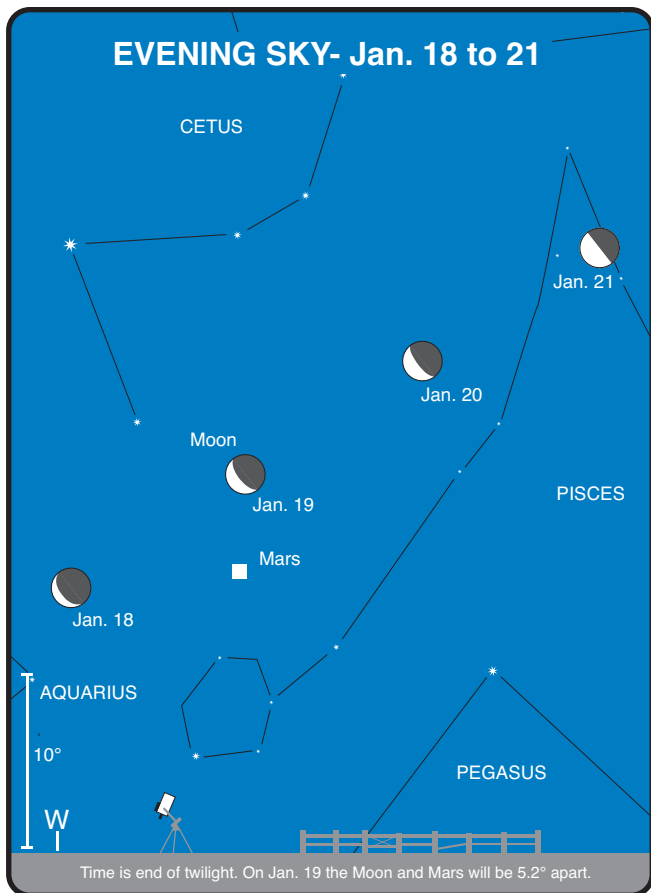
9th	11 PM	m.p. 9 Metis 0.2° N of star Pollux
12th	9 AM	Mercury greatest elongation E (19°)
13th	11:29 PM	New Moon
14th		Mercury at ascending node
14th	10 PM	Venus in superior conjunction
15th	Noon	Mercury 4° N of Moon
16th	8 AM	Uranus 4° N of Moon
17th	3 AM	Vesta stationary
18th	7 PM	Mercury stationary
18th	7 PM	Moon at apogee
19th	8 AM	Mars 5° N of Moon
19th		Mercury at perihelion
22nd	3:46 AM	First Quarter Moon
23rd		m.p. 29 Amphitrite 0.3° S of NGC 6520 (OC) in Sagittarius
25th	2 AM	Saturn 0.08° S of Moon; occultation
25th		Venus at aphelion
27th	5 AM	Jupiter 0.9° S of Moon; occultation
28th	5 AM	Mercury in inferior conjunction
28th	Midnight	Neptune in conjunction with Sun
29th	8:50 AM	Full Moon
29th		Mercury at greatest latitude North
30th		Mars 0.1° NW of NGC 128 (SG) in Pisces
30th	7 PM	Moon at perigee

All times are AEST. For daylight saving add 1 hour.



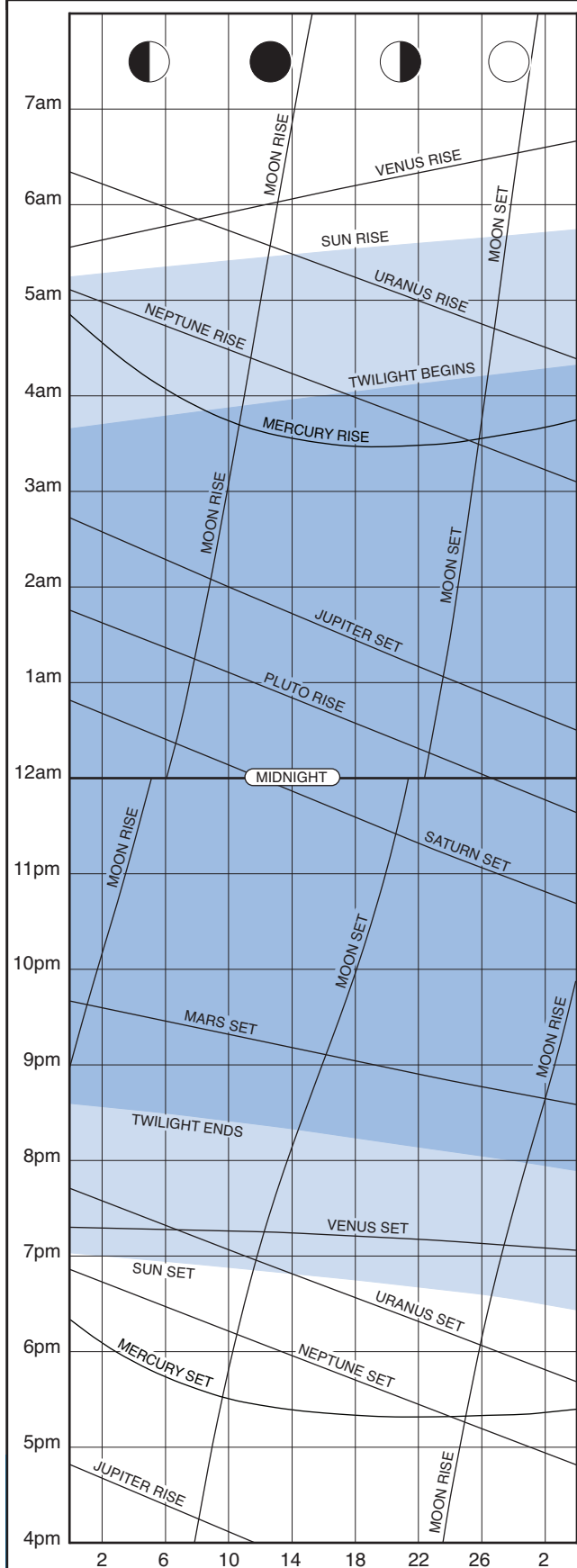


All times are AEST. For daylight saving add 1 hour.



FEBRUARY

RISE/SET CHART



All times are AEST. For daylight saving add 1 hour.

FEBRUARY HIGHLIGHTS

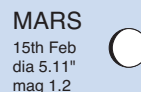
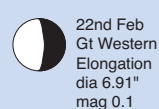
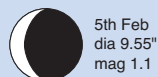
- Mercury at its most favourable in the morning sky
- Mercury and Neptune in same low power telescope field
- Venus returns to evening twilight late in month
- Saturn near Aldebaran
- Saturn, Moon and Aldebaran form a neat triangle

THE MOON

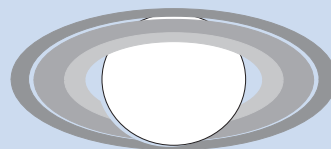
- 4th Last Quarter
- 12th New Moon
- 15th Moon at apogee (furthest from Earth – 406,363 km distant, angular size 29.4')
- 20th First Quarter
- 20th Occultation of minor planet Vesta by the Moon, visible from Northern Hemisphere
- 21st Occultation of Saturn by the Moon, visible from the Americas
- 22nd Occultation of Jupiter by the Moon, visible from Northern Hemisphere
- 27th Full Moon
- 28th Moon at perigee (closest to Earth – 356,897 km distant, angular size 33.5')

APPEARANCE of the PLANETS

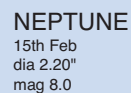
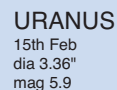
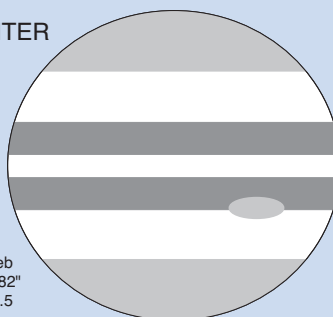
MERCURY



SATURN



JUPITER



THE PLANETS

MERCURY will be at its most favourable in the morning sky this year from mid-February to mid-March. The planet reaches its greatest elongation west of the Sun on the 22nd (27°), providing an entire month with the planet in dark sky before twilight. On the 10th, the 27-day old thin crescent Moon will appear 6.8° above the planet (see Sky View). A rare opportunity to observe the Sun's closest planet and one of its most distant, Neptune, in the same low power field occurs on the 25th when they appear just 0.5° apart.

VENUS returns to the evening twilight this month, but remains too close to the Sun for observation. Keen observers with an unobstructed western horizon may try spotting the planet just after sunset towards month-end.

MARS, in Pisces, is visible in the early evening northwestern sky, setting around 9pm. On the 17th, the 4-day old crescent Moon will be situated 4.5° above the Red Planet (see Sky View).

JUPITER is prominent in the mid-evening northern sky in Gemini, setting around 1.30am mid-month. The 10-day old Moon appears 5.5° from the planet on the 23rd (see Sky View).

SATURN in Taurus again lingers within 4° of the 1st magnitude star Aldebaran during the month, in the NW evening sky. On the 20th, the First Quarter Moon will be 7.8° from the ringed planet, and on the following evening closer at 5.5° forming a right angle triangle with Aldebaran (see Sky View).

ASTROPHOTOGRAPHER JOE CAUCHI

For a number of years we, at Quasar, have been displaying the magnificent astrophotography of Sydney amateur, Joe Cauchi. Joe started his passion for astronomy back in the early 70's with a 4.5 inch Tasco telescope. This soon gave way to a 200mm Newtonian. However, he soon lost interest having fallen into the common trap of knowing only a few well-known objects and hence running out of things to observe! His flame was rekindled when he discovered the classic book 'Hartung's Astronomical Objects for Southern Telescopes' * and by joining the Astronomical Society of NSW. Hartung's pointed out a whole universe of new objects and the ASNSW brought the benefits of surrounding yourself with people with a common passion. Incidentally, this was the start of a long-term association with the society, with Joe currently a vice-president. By the mid 70's, aperture fever had struck and he had built himself a home made mount and installed a 250mm f/5 reflector.

In 1979 fellow amateur Terry Clark first introduced Joe to the world of astrophotography. Terry showed him how to get great photos of the Moon. This work was easy, no guiding of the telescope was needed with the Moon and normal, fine grain films could be used. Unfortunately, our closest celestial neighbour only has so many phases to be 'snapped' and Joe was soon looking for further challenges. The next logical progression was to do 'piggy-back' work using a 200mm telephoto lens, but there were only so many wide field shots of the Milky Way he could do.

He soon made the jump to guided, prime focus, deep sky objects. It was now 1980 and Joe found he needed some very fast film. Initially he used black and white films such as Kodak

Tri X or the spectroscopic 103ae or 103ao (the 103 films are no longer available). Being black and white he could easily process the film himself - which he continues to do today. These early films were fast, but very grainy. With the introduction of Kodak 2415, in combination with the gas hypersensitization (or hypered) process, there was at last a fast, fine grain film that didn't suffer from reciprocity failure (the film didn't get 'tired', compared to normal films, on long exposures). Kodak 2415 was also black and white but fortunately Joe was more interested in shooting galaxies, which really don't need colour. At the time he did experiment with hypered colour films but he was never really happy with the resulting colour balance. Joe found the combination of the fine grain film and the good seeing of the ASNSW's Bowen Mountain Observatory site produced sharp, detailed images.

In the late 80's, for about 3 years, he experimented with a Wright-Schmidt 5.5 inch f/3.8 camera. This gave very fast, sharp, 3° wide field views of the sky, but most objects, such as galaxies, were too small to see any detail in the photographs.

In the early 90's Joe changed his 250mm f/5 mirror to a 250mm f/4. He immediately saw a marked increase in speed with a wider field. Once again this suited the finer grain films. All of the images used on page 1 of the Quasar yearbooks, to date, have been taken with this mirror, using hypered 2415, with up to 45 mins exposure. All pictures were taken at the ASNSW's superb dark sky site Wiruna near Ilford NSW.

In 1999, in the tradition of a true deep sky fanatic that is 'too much aperture is never enough', Joe commenced his most ambitious project - a 400mm f/4.5 scope. It has taken 2 years to overcome the numerous teething problems. The telescope has great potential and he is planning to go after the faint Abell galaxy clusters in the future.

Does Joe see CCD cameras in his future? The answer is yes. Although this technology is easier to use compared to traditional films; he still has some technical problems to overcome.

In conclusion, Joe is the first to admit that astrophotography is a hard, expensive and frustrating hobby. Despite all this, he has taken hundreds of photographs over the years and the thing that really counts is that slight smile when Joe proudly pulls out a folder of prints.

* Hartung's book has been fully revised recently by Australia's famous astrophotographer, David Malin and David Frew.



Joe with his 250mm telescope.

FEBRUARY

URANUS is in conjunction on the 14th, and moves into the morning twilight sky mid-month.

NEPTUNE, after conjunction last month, moves into the morning twilight. Late in the month, Neptune and Mercury have a close encounter (see Mercury).

PLUTO rises around 1am in Ophiuchus.

MINOR PLANETS at opposition this month include: 3 Juno on the 8th at magnitude 8.4 in Hydra, 8 Flora on the 26th at magnitude 9.2 in Leo and 28 Bellona on the 22nd at magnitude 10.1 in Leo. During the month 8 Flora visits the Leo group of galaxies.

COMETS

Comet C/2000 WM1 (LINEAR) moves quickly from Telescopium into Sagittarius in the morning sky this month. On 18th February, LINEAR is about three degrees from the globular cluster M55. By month's end, the comet should have faded from 7th to 8th magnitude.

Comet 7P/Pons-Winnecke should first become visually observable in large telescopes this month as it brightens from 15th to 13th magnitude. The comet is located in the morning sky, initially only a few degrees from 3rd magnitude Alpha Serpentis. It then moves through Serpens, Hercules, and into Ophiuchus.

Comet 19P/Borrelly can only be observed from northern Australia as it fades from 13th to 14th magnitude during February. The comet moves from Canes Venatici into Ursa Major this month.

Comet 96P/Machholz 1, in all probability, will escape detection by amateurs at this return, particularly post-perihelion, although it will be in the field of the orbiting SOHO observatory in early January. Nevertheless, CCD users may like to start trying for the comet in early February, a month after perihelion, when it is 13th magnitude and rising around the beginning of astronomical twilight. Comet Machholz 1 spends February in the constellation of Aquila, and will be fainter than 15th magnitude by month's end.

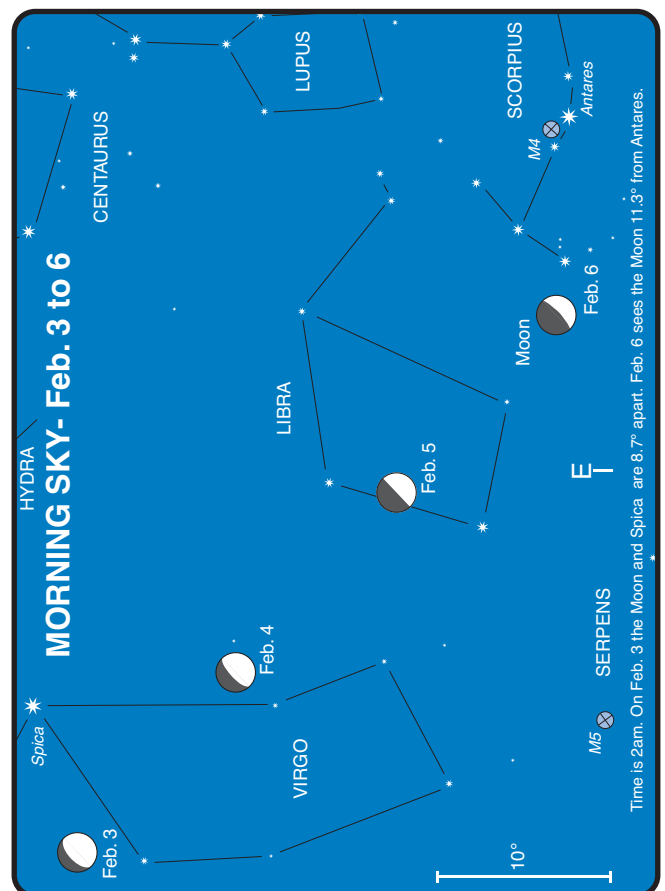
METEOR SHOWERS

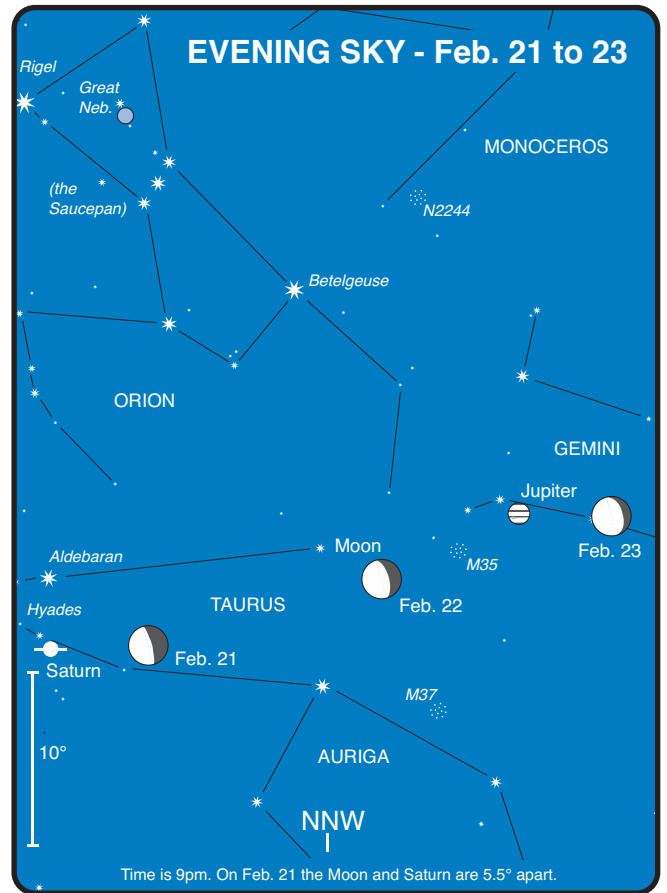
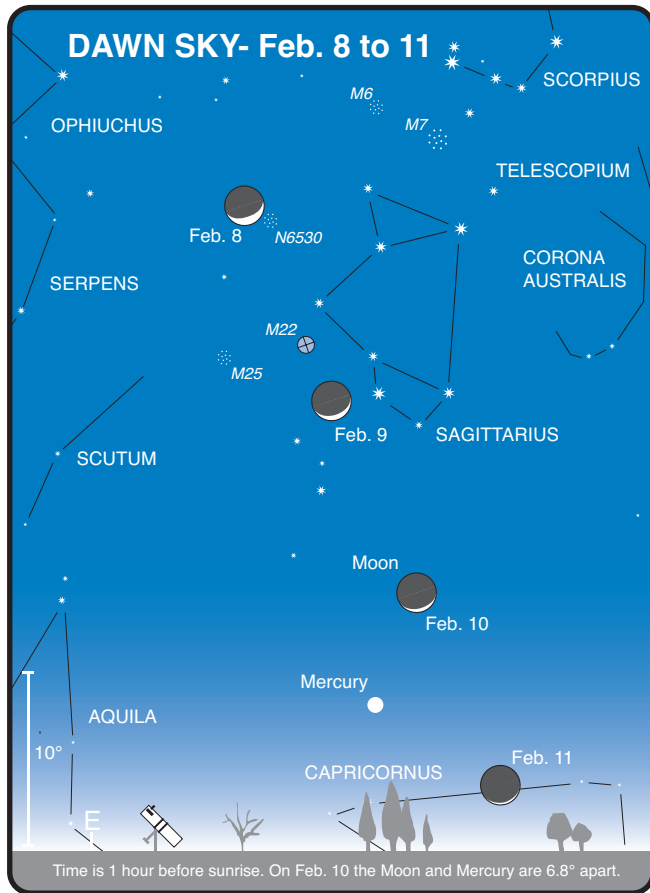
The **alpha Centaurids** are active from 28th January through to 21st February, with maximum on the 8th. Their zenith hourly rate is unpredictable, around 5 to 10 per hour at best, but high rates sometimes occur every 4 to 6 years. Most recently, in 1974 and 1980 the rate was 20 to 30 per hour. This increase is always temporary, lasting no more than 2 to 3 hours. The shower is noted for its brightly coloured fireballs that frequently reach negative magnitudes (up to -3 or more). They are predominantly yellow or blue, but their range can cover the entire spectrum. The alpha Centaurids are also well known for their long lasting trains (about 25 to 30 percent of the meteors) which may last from a few seconds to several minutes. Being circumpolar, the shower is visible throughout the night.

The **delta Leonids** are not well placed for southern observers, but with the radiant near the 'sickle' or 'head' of Leo, it will be above the northern horizon for a few hours late evening and early morning. With predominately faint meteors this shower is considered a minor one, active from 15th February to 10th March. Maximum is on the 24th but only a low zenith hourly rate of around 2 can be expected.

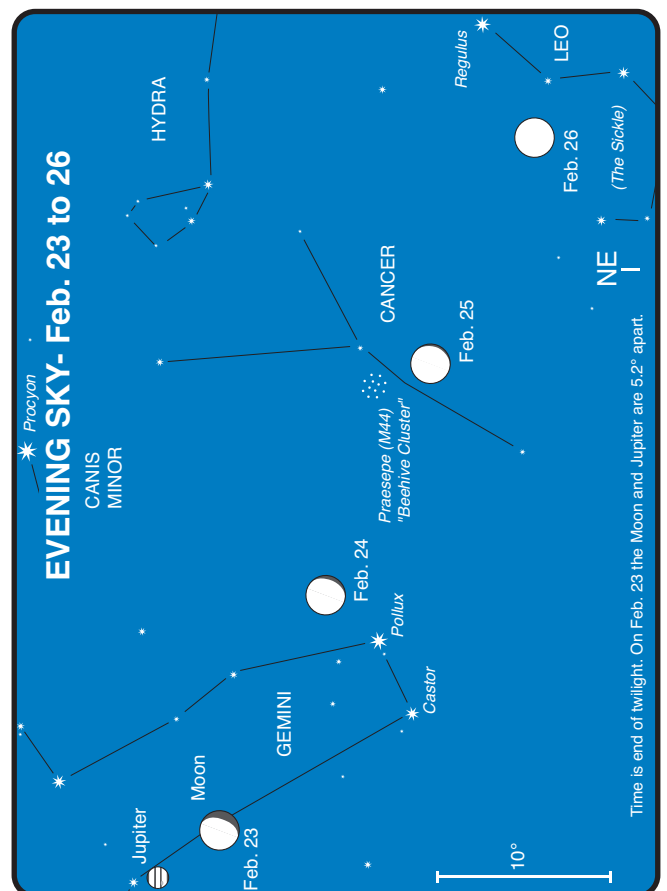
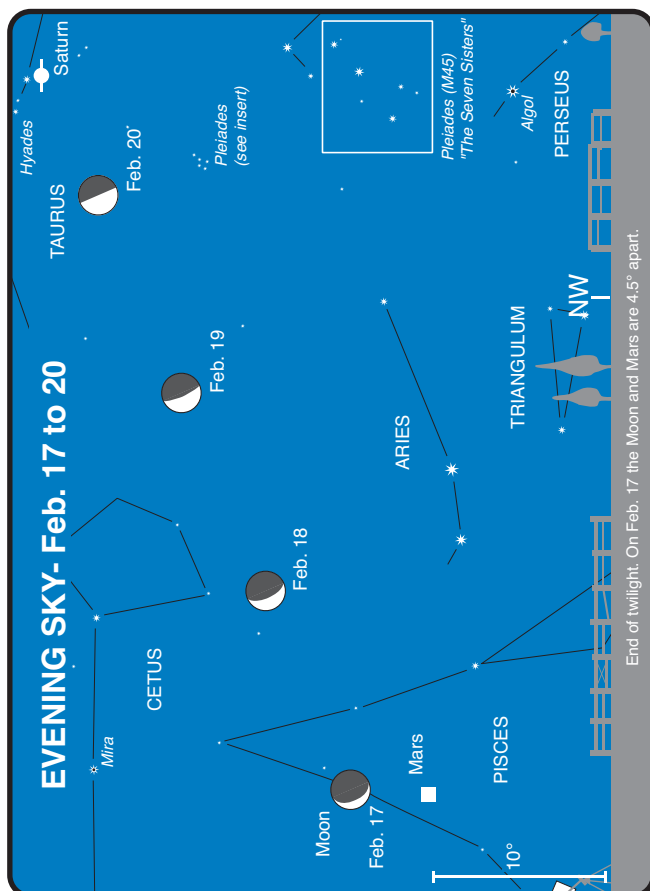
DIARY

4th	11 PM	m.p. 8 Flora 0.9°SW of NGC 3489 (EG) in Leo
4th	11:33 PM	Last Quarter Moon
8th	8 PM	Mercury stationary
8th	8 PM	Saturn stationary
9th	11 PM	m.p. 8 Flora 0.9°NE of NGC 3412 (EG) in Leo
10th		Mars at ascending node
10th	3 PM	Mercury 5°N of Moon
11th	11 AM	Juno at opposition
12th	5:41 PM	New Moon
13th	11 PM	m.p. 8 Flora 0.8°NE of NGC 3377 (EG) in Leo
14th	3 AM	Uranus in conjunction with Sun
15th	8 AM	Moon at apogee
16th		Venus at greatest latitude South
16th		m.p. 18 Melpomene 0.7°S of NGC 6822 (IG) in Sagittarius
16th		m.p. 29 Amphitrite 1°S of star Phi Sagittarii
16th	11 PM	Ceres in conjunction with Sun
17th	10 AM	Mars 5°N of Moon
20th		Mars 0.6°SW of NGC 524 (EG) in Pisces
20th	10:02 PM	First Quarter Moon
20th	11 PM	Vesta 0.6°S of Moon; occultation
21st	10 AM	Saturn 0.2°S of Moon; occultation
21st		Mercury 0.2°E of m.p. 15 Eunomia
22nd	2 AM	Mercury greatest elongation W (27°)
22nd		Mercury at descending node
23rd	Noon	Jupiter 0.9°S of Moon; occultation
24th	11 PM	Mercury 0.5°S of Neptune
27th	7:17 PM	Full Moon
28th	6 AM	Moon at perigee
28th		m.p. 3 Juno 0.3°NE of NGC 2775 (SG) in Cancer



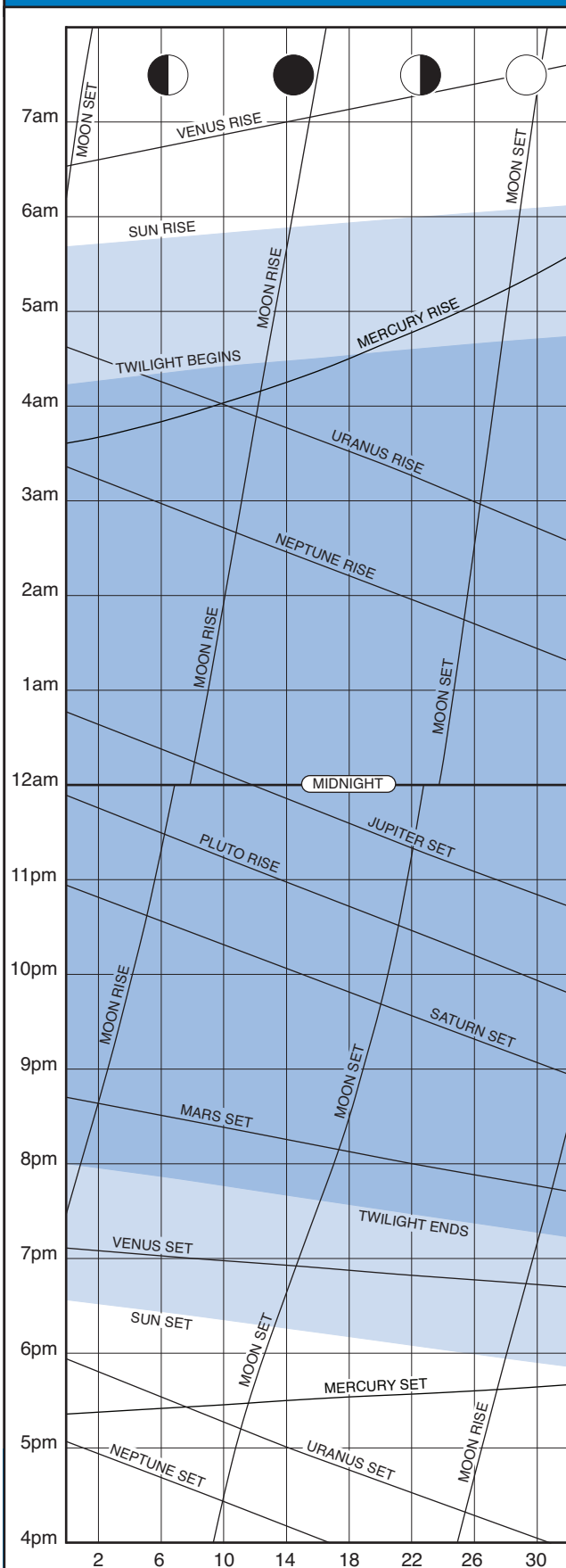


All times are AEST. For daylight saving add 1 hour.



MARCH

RISE/SET CHART



All times are AEST. For daylight saving add 1 hour.

MARCH HIGHLIGHTS

- Mercury and Uranus close in the morning sky
- Last chance to see Mercury in the morning sky (until June)
- Venus returns to the evening sky
- Venus, Mars, Saturn & Jupiter distributed along four neighbouring zodiacal constellations
- Saturn and Moon very close
- Saturn and minor planet Vesta very close

THE MOON

- 6th Last Quarter
- 14th Moon at apogee (furthest from Earth – 406,707 km distant, angular size 29.8')
- 14th New Moon
- 20th Occultation of Saturn by the Moon, visible from parts of Asia
- 20th Occultation of minor planet Vesta by the Moon, visible from parts of Northern Hemisphere and Asia
- 22nd First Quarter
- 22nd Occultation of Jupiter by the Moon, visible from parts of Northern Hemisphere
- 28th Moon at perigee (closest to Earth – 357,010 km distant, angular size 33.5')
- 29th Full Moon

APPEARANCE of the PLANETS

MERCURY



5th Mar
dia 5.96"
mag -0.1



15th Mar
dia 5.43"
mag -0.3



25th Mar
dia 5.10"
mag -0.7

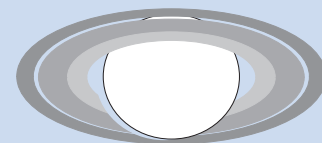


VENUS
15th Mar
dia 10.05"
mag -3.9



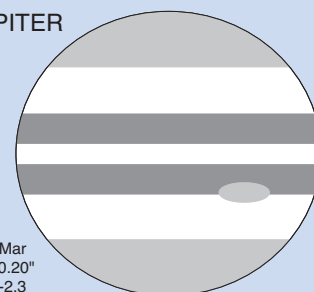
MARS
15th Mar
dia 4.59"
mag 1.4

SATURN



15th Mar
dia 17.94"
mag 0.1

JUPITER



15th Mar
dia 40.20"
mag -2.3

URANUS

15th Mar
dia 3.38"
mag 5.9

NEPTUNE

15th Mar
dia 2.22"
mag 8.0

PLUTO

15th Mar
dia 0.11"
mag 13.8

THE PLANETS

MERCURY, for the first half of March, maintains a good angular distance from the Sun, and remains easily visible in the eastern morning sky. On the 9th and 10th Mercury comes within 1.4° of Uranus (do not confuse Uranus with the brighter 5th magnitude star Mu Capricorni, situated just 0.3° from the greenish disk of the planet). On the 12th, the 27-day old thin crescent Moon appears 3.3° above the planet (see Sky View). During the course of March, Mercury travels from Capricornus to Aquarius and finally into Pisces at month-end.

VENUS is close to the Sun early in the month, but should not be difficult to detect in the western evening twilight from mid month onwards. On the Ides of March (15th), the slender crescent 1-day old Moon and Venus will make a splendid sight 3.1° apart, in the very early twilight. Interestingly at this time four planets are spread along four neighbouring zodiacal constellations as follows: (from west to north) Venus in Pisces, Mars in Aries, Saturn in Taurus, and Jupiter in Gemini.

The **EARTH** is at its autumnal equinox on the 21st. The Sun rises and sets due east and west and day and night are equal.

MARS, in Aries, is visible in the northwestern evening sky, setting about two hours after the Sun. On the 18th, the 4-day old crescent Moon will be 3.6° above the Red Planet.

JUPITER is situated in the mid-evening northern sky in Gemini, 4° from the rich compact star cluster Messier 35 (NGC2168), setting around midnight. On the 22nd, the First Quarter Moon appears 2° from the planet (see Sky View). Incidentally, a few degrees from Jupiter's position (just over the border in Taurus) was where Sir William Herschel discovered Uranus 221 years ago this month.

SATURN is in Taurus, 4° below the first magnitude star Aldebaran in the northwestern evening sky. On the 20th, the 6-day old Moon appears 1.3° below the planet (see Sky View).

On the 19th, there is an ideal chance to view an asteroid (minor planet), when Vesta is within only 0.1° of Saturn. Do not confuse Saturn's moon Titan with Vesta as both are of similar magnitude (around 8th), the moon is between the asteroid and the planet. On the following evening Vesta is now on the opposite side of Saturn and a little further away than on the 19th.

URANUS rises in the late morning eastern sky. Since 1996, Uranus has been confined within the boundaries of the constellation of Capricornus. At month-end the planet moves into Aquarius and remains there until mid-August when it returns to Capricornus. On the 9th, Uranus and Mercury have a close encounter (see Mercury).

NEPTUNE rises about an hour before and 16° above Uranus in the morning sky. Neptune, moving slower than Uranus, has resided in Capricornus since late 1998; it finally follows Uranus into Aquarius in 2010.

PLUTO now rises before midnight. The planet will be in retrograde motion from the end of the month until the end of August (see retrograde motion in Part II).

MINOR PLANETS at opposition this month include 27 Euterpe on the 12th at magnitude 9.4 in Leo. 18 Melpomene has some interesting deep sky encounters in Aquarius this month.

COMETS

Comet 7P/Pons-Winnecke is a morning object in March, moving through the constellations of Ophiuchus and Serpens. Brightening from 13th to 12th magnitude as the month progresses, the comet is little more than a degree from 4th magnitude Sigma Ophiuchi around 11th March. A week later, Pons-Winnecke is less than a degree from Gamma Ophiuchi.

Comet C/2000 WM1 (LINEAR) is rising higher in the sky each morning as it moves away from the Sun. The comet moves through Sagittarius into neighbouring Aquila. On 7th March, LINEAR is less

A RED LIGHT DISTRICT?

Why Use a red torch.....

The dark-adapted eye is insensitive to longer wavelengths of light and this is why the use of a red light when working at a telescope is so effective. The reason is the human eye is made up of sensors that react to different types of light. These sensors come in two types, rods and cones. Cones react primarily to colours and work best in bright conditions such as daylight. Rods on the other hand sense light in shades of black and white and continue to work well at low levels of light. Another way to help preserve dark adaptation, when taking a break from observing, is to wear red goggles. Although the pupils dilate relatively quickly it can take up to 20 minutes, depending on the individual, to achieve complete dark adaptation.

How to make a red torch.....

The simplest way to make a red torch is buy a torch from a supermarket, toy store or any other store that might take your fancy, and some red cellophane and a rubber band. Place the cellophane over the end of the torch and hold it in place with the rubber band.

One problem with this is that the cellophane will tear and the torch will not last. There are a few alternatives to the cellophane torch.

Buy a good quality torch, for example a Mini-Mag Light or similar. These torches are great, they take two AA batteries that last for ages. The torch will cost about \$30-\$50 and it really is worth it. The next step is to visit your local hobby shop and purchase a jar of clear red paint; this should cost you under \$5. The next part can be done in two ways, both will require you to disassemble your

torch and both will work on most torches, including the one from the toy store that costs \$2. It's a good idea to have some blue tack or polystyrene handy for this. The globe in a Mag Light is a small glass bulb on the end of a two-wire element. Gently push the elements into the blue tack or polystyrene. Once firmly inserted dip the globe into the clear red paint, leave the globe to dry. This should be repeated 2 to 3 times, giving the globe plenty of time to dry. The advantage of doing this is that in the base of the Mag light there is a spare globe, so when you need red light, you have it and when you need white light swap the globe. Another advantage is that the Mag light has a removable reflector that makes the torch work like a candle. This is handy as it's not always practical to hold a torch, especially when you have lots of people that need it at the same time.

The other option is a bit harder; you will need the same ingredients as well as a hobby paintbrush. The idea here is that the glass that covers the globe in your torch is to be painted. If you are not worried about the torch, slap some paint on while the glass is in the torch. That way you might get some paint on the torch housing. The other way is to take the glass out and stick it on a piece of blue tack, paint one side and let it dry. It's important that it dries completely before sticking the painted surface on to the blue tack. Repeat 2 to 3 times as necessary.

Another alternative is to buy a torch that is specific for the purpose. Some of these have red LEDs instead of a globe. The commercially available 'Skylite' torch has 2 pairs of LEDs, one pair is red the other white which can easily be switched between. There is also a control to dim the torch.

Daniel Tickell

MARCH

then a degree from 4th magnitude Rho 1 Sagittarii. In March and April, LINEAR has a few encounters with star clusters in Aquila. By the end of March, the comet is similarly less than a degree from the globular cluster NGC 6760. During the month, LINEAR should fade from 8th to 10th magnitude.

METEOR SHOWERS

The **Gamma Normids** are active between 25th February and 22nd March. For most of the period the rate is low, and members are difficult to sort out from the background sporadic activity. The peak occurs on March 13, when rates can reach 3 to 8 per hour. Generally, the Gamma Normids are bright and chiefly yellow, white or orange with about 15% leaving trains. Since the constellation Norma doesn't reach a reasonable altitude until late evening, the shower is best viewed after midnight.

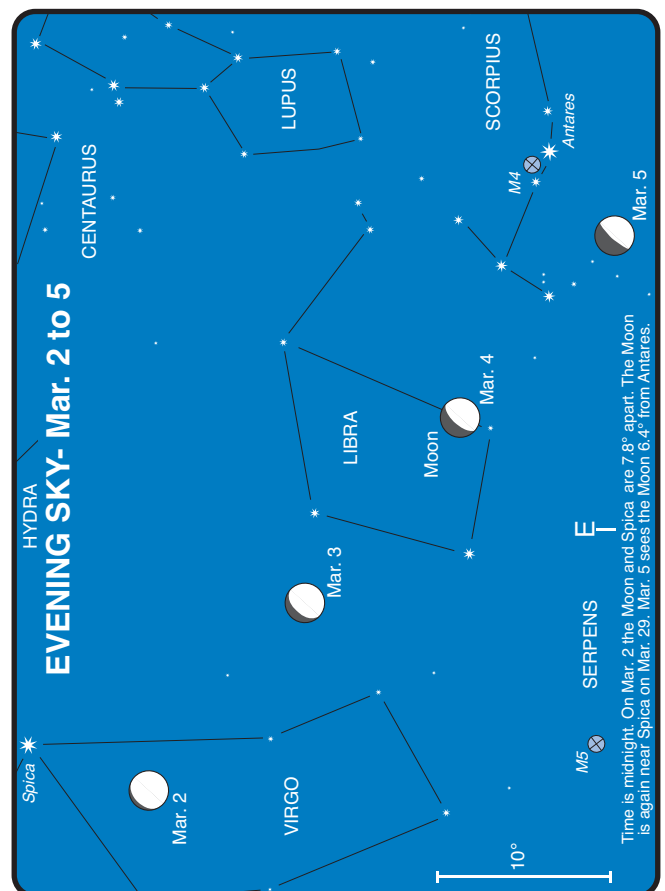
The **Virginids** are active from 25th January through to 15th April, with several peaks of maximum activity over the period. The radiant is near 1st magnitude Alpha Virginis (Spica), and the shower is best seen from late evening and into the morning hours. A zenith hourly rate of 5 slow meteors during peaks can be expected.

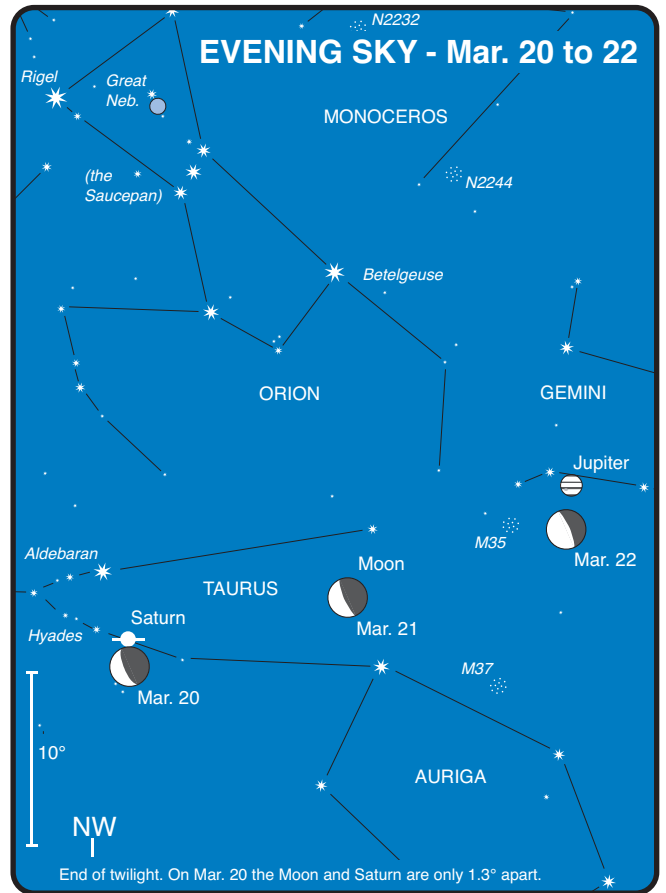
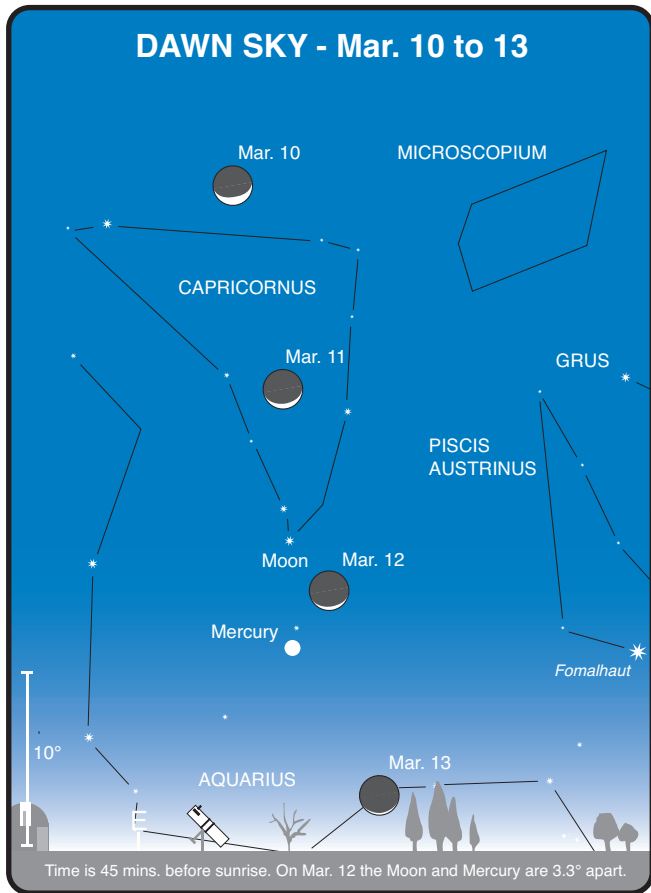
DIARY

1st		m.p. 29 Amphitrite 0.2°SE of star Tau Sagittarii
2nd	1 AM	Jupiter stationary
4th		Mercury at aphelion
4th		Neptune 0.5°S of m.p. 15 Eunomia
5th		m.p. 18 Melpomene 0.8°N of star Beta Capricorni
6th	3 AM	m.p. 25 Phocaea 0.6°S of star Eta Ophiuchi
6th	11:24 AM	Last Quarter Moon
9th	1 PM	Mercury 1.2°S of Uranus
10th	7 PM	Neptune 4°N of Moon
11th		m.p. 4 Vesta 0.1°N of NGC 1554 (Neb.) in Taurus
12th	3 AM	Uranus 4°N of Moon
12th	11 AM	Mercury 3°N of Moon
13th	3 AM	Comet 57P/du Toit-Neujmin-Delporte 0.7°S of NGC 6440 (GC) in Sagittarius
14th	11 AM	Moon at apogee
14th	12:02 PM	New Moon
15th	5 AM	Comet 46P/Wirtanen 0.02°W of m.p. 1 Ceres
17th		Comet 7P/Pons-Winnecke 0.5°S of NGC 6426 (GC) in Ophiuchus
18th		m.p. 18 Melpomene 0.3°NW of Aqr Dwarf (IG) in Aquarius
18th		m.p. 20 Massalia occulted by the Sun (not observable)
18th	11 AM	Mars 4°N of Moon
19th	9 PM	Saturn 0.1°NE of m.p. 4 Vesta
20th		m.p. 2 Pallas 0.3°SE of NGC 6934 (GC) in Delphinus
20th	8 PM	Saturn 0.5°S of Moon; occultation
20th	8 PM	Vesta 0.5°S of Moon; occultation
21st	5 AM	Equinox
21st	4 PM	Pluto stationary
22nd		m.p. 18 Melpomene 0.4°N of NGC 6981 (GC) in Aquarius
22nd	12:28 PM	First Quarter Moon
22nd	10 PM	Jupiter 1.1°S of Moon; occultation
23rd		Mercury 0.2°E of NGC 7596 (SG) in Aquarius

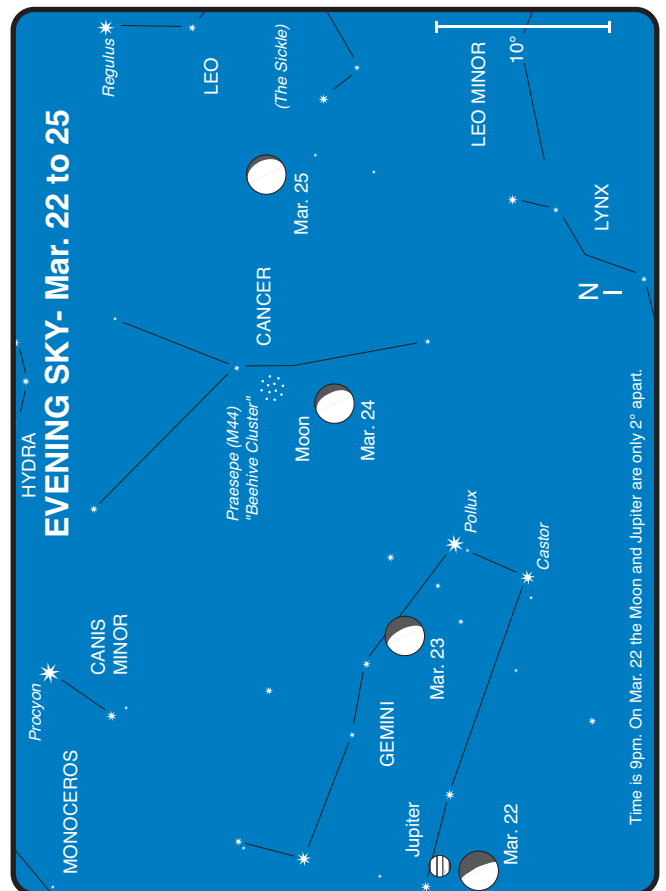
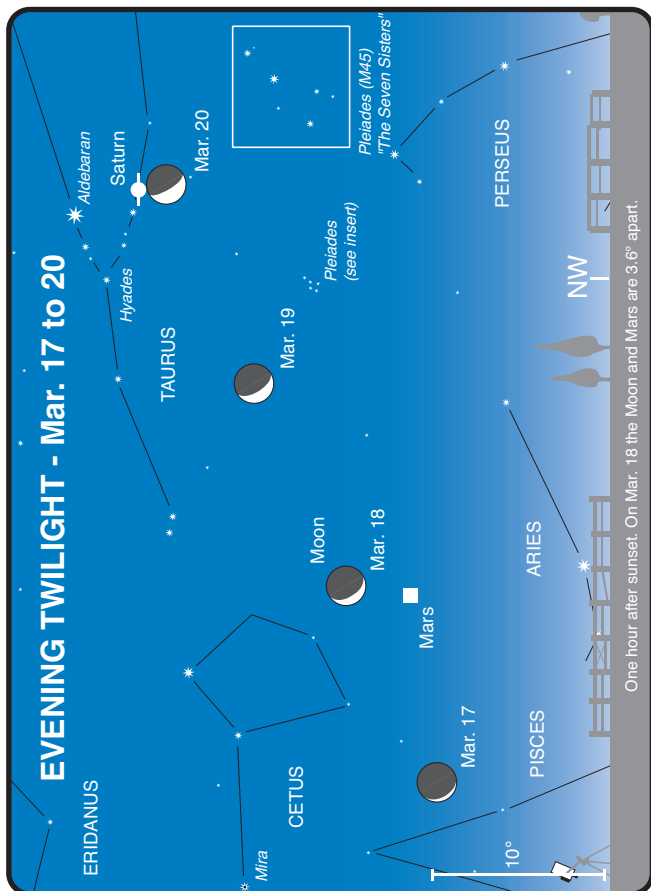
23rd	10 PM	Juno stationary
24th		Mercury at greatest latitude South
24th		m.p. 18 Melpomene 0.8°N of M73 (OC) in Aquarius
27th		m.p. 18 Melpomene 0.2°SW of Saturn Nebula (PN) in Aquarius
28th	6 PM	Moon at perigee
29th	4:25 AM	Full Moon
29th		m.p. 6 Hebe 1°SE of NGC 6664 (OC) in Scutum
31st	3 AM	Comet C/2000 WM1 (LINEAR) 0.5°E of NGC 6760 (GC) in Aquila

All times are AEST. For daylight saving add 1 hour.



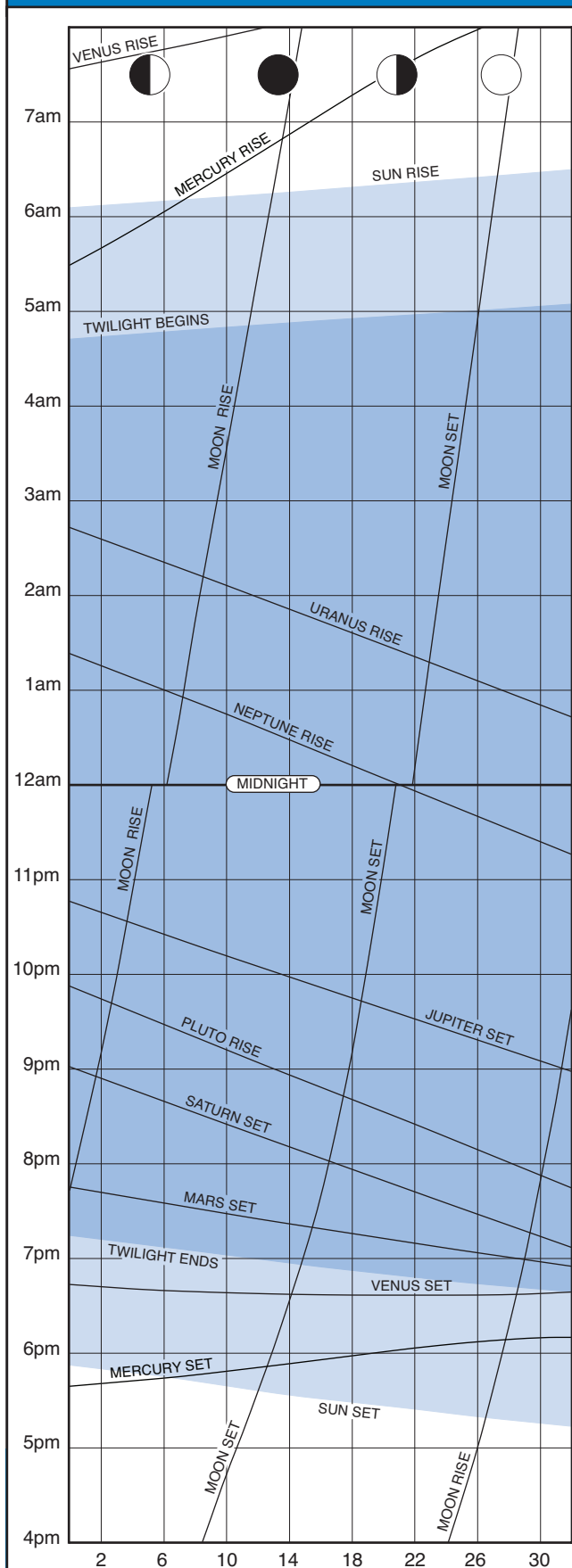


All times are AEST. For daylight saving add 1 hour.



APRIL

RISE/SET CHART



All times are AEST.

APRIL HIGHLIGHTS

- Mercury, Venus, Mars and Saturn all in Taurus late in month
- Venus brilliant in the evening twilight
- Mars and Saturn close at month-end

THE MOON

- 5th Last Quarter
- 10th Moon at apogee (furthest from Earth – 406,408 km distant, angular size 29.6')
- 13th New Moon
- 17th Occultation of Saturn by the Moon, visible from Northern Hemisphere
- 17th Occultation of minor planet Vesta by the Moon, visible from Northern Hemisphere
- 20th First Quarter
- 26th Moon at perigee (closest to Earth – 360,085 km distant, angular size 33.5')
- 27th Full Moon

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 7th



5th Apr
dia 5.00"
mag -1.8



15th Apr
dia 5.32"
mag -1.6



25th Apr
dia 6.33"
mag -0.7

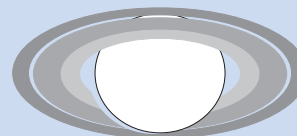


VENUS
15th Apr
dia 10.81"
mag -3.9

MARS

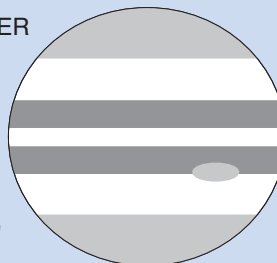
15th Apr
dia 4.17"
mag 1.6

SATURN



15th Apr
dia 17.12"
mag 0.1

JUPITER



15th Apr
dia 36.51"
mag -2.1

URANUS

15th Apr
dia 3.43"
mag 5.9

NEPTUNE

15th Apr
dia 2.25"
mag 7.9

PLUTO

15th Apr
dia 0.11"
mag 13.8

THE PLANETS

MERCURY is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 7th, and thereafter moves into the evening sky. Mercury steadily gains altitude after conjunction, but will be difficult to see in the twilight until month-end. After the 27th, with a good unobstructed northwestern horizon, Mercury may be glimpsed soon after sunset at low altitude. Strung along the ecliptic northwards above Mercury are Venus, Mars and Saturn, all four planets being in Taurus at this time.

VENUS is now easily visible in the evening twilight. The planet moves from Aries into Taurus late in the month, joining Mars and Saturn. Next month the trio provide some interesting and close conjunctions. On April 14th, the 1-day old thin crescent Moon appears 6° south of the planet, and on the following evening 5.7° to the north (see Sky View).

MARS is low in the early evening twilight, setting 30 minutes after the end of twilight. It moves from Aries into Taurus during the first week of April. On the 16th, the 3-day old crescent Moon appears 3.7° from Mars (see Sky View). By the 30th, the Red Planet will be located 3° below Saturn. Venus and Mercury are also nearby but lower in altitude and westward.

JUPITER can be found in the NW evening sky in Gemini, setting around 10pm mid-month. The 6 day old Moon will be 5.8° from Jupiter on the 19th (see Sky View).

SATURN is in the NW early evening sky, setting about 2 hours ahead of Jupiter. It begins April as the only planet in Taurus, but is joined by Mars, Venus and Mercury by month-end. On the 16th, the 3-day old crescent Moon is 6.8° south of Saturn (and nearer to Mars), on the following evening a little closer at 6.3° to the north (see Sky View).

URANUS and **NEPTUNE**, in Aquarius and Capricornus respectively, pass an uneventful month in the early morning eastern sky.

PLUTO rises in the mid-evening and transits the meridian (due north) around 3.30am mid-month.

COMETS

Comet 7P/Pons-Winnecke brightens from 12th to 11th magnitude this month in the morning sky. Visible from shortly after midnight, the comet moves through Serpens and Aquila. On 11th April, Pons-Winnecke is two degrees from the globular cluster NGC 6760. A week later, the comet is a similar distance from 4th magnitude Iota Aquilae. In late April, the comet is less than four degrees from 3rd magnitude Theta Aquilae.

Comet C/2000 WM1 (LINEAR) rises before midnight during April as it moves from Aquila into Hercules. In March and April, LINEAR has a few encounters with star clusters in Aquila. During this month, the comet should fade from 10th to 11th magnitude.

METEOR SHOWERS

The **Lyrids** are a northern shower, but can be observed south of the equator. They are best seen between 2am and dawn from the 16th to 25th April, with maximum on the 22nd. Maximum rates may only last an hour or so, and typically the zenith hourly rate is around 15. The Lyrids have on occasion produced higher rates, and because of their erratic nature, they are a shower to be watched. In 1982 American observers observed a short peak of 90 per hour.

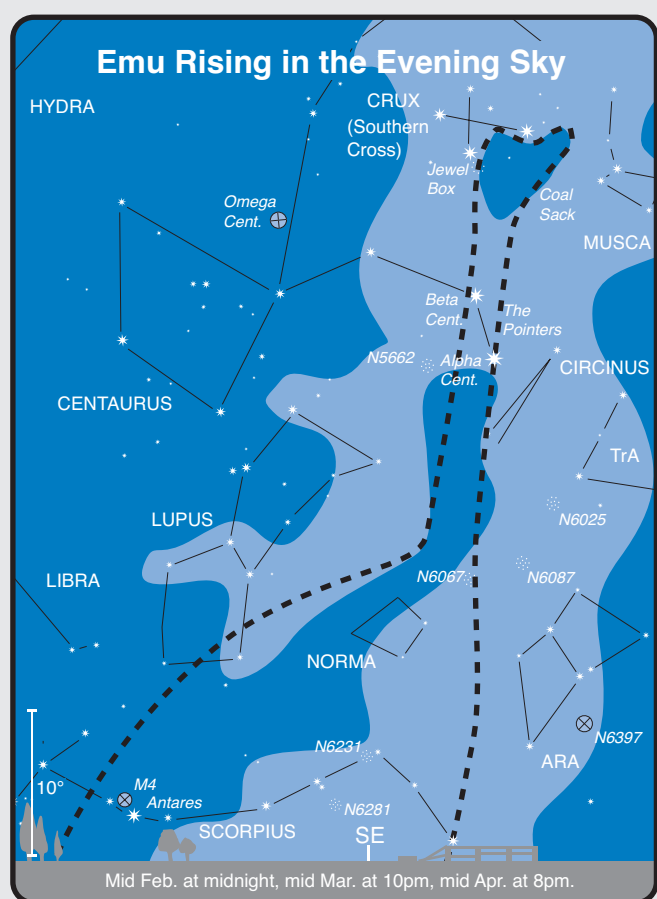
THE CONSTELLATION OF THE EMU

The Australian aborigines had their own version of the zodiac thousands of years before the Europeans dreamed up our modern day interpretation of the constellations. The aborigines had a sky consisting of some 40 different native birds and animals which included eagles, parrots, lorikeets and dancing men. Probably the most conspicuous constellation was that of the Emu.

Unlike many of the Greek and Roman figures allotted to the star patterns, the Emu really does resemble this Australian native creature. The animal is made up of many dark bands of nebulae that are silhouetted against the glow of our own galaxy, the Milky Way.

To see this bird you need to be well away from the light polluted skies of large towns and cities (if you can't see the Milky Way - forget about finding this animal). The Emu can be seen sitting on the southeastern horizon in the late summer and autumn evening sky. It is quite large - extending half way up the sky. Its head consists of what is probably the most distinctive dark nebula in the southern skies, the Coal Sack, near the Southern Cross. It is well shaped, even showing a beak, and a fairly conspicuous 6th magnitude star for an eye. From there the neck runs down through the pointers and then widens out to the body in Scorpius.

It is unique. For example, none of the modern day constellations are made up entirely of nebulae i.e., no stars! Considering its terrestrial counterpart is very much earth-bound, the Emu has no problems taking flight, passing overhead, as the Southern Hemisphere moves into its brilliant, early evening winter skies.

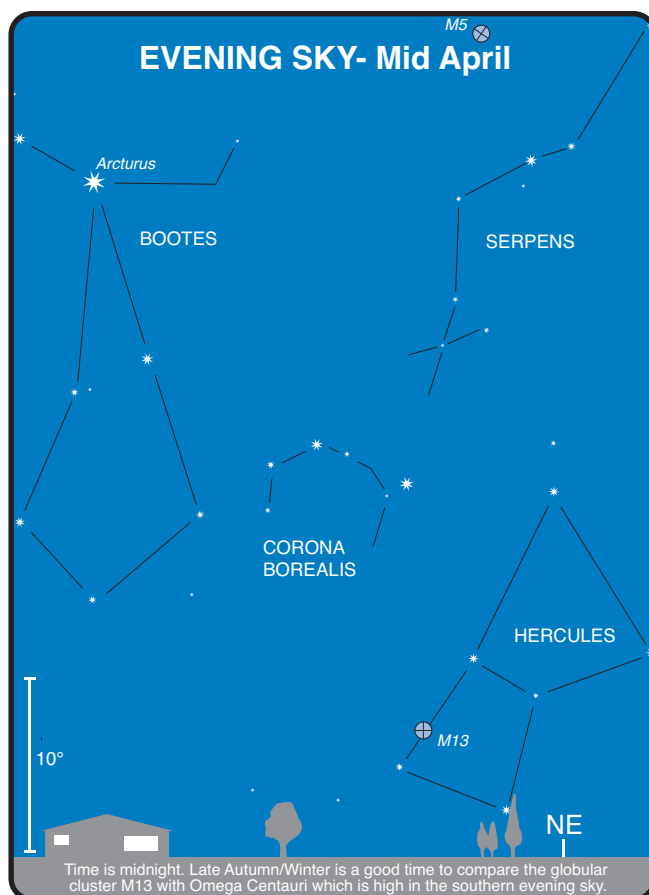
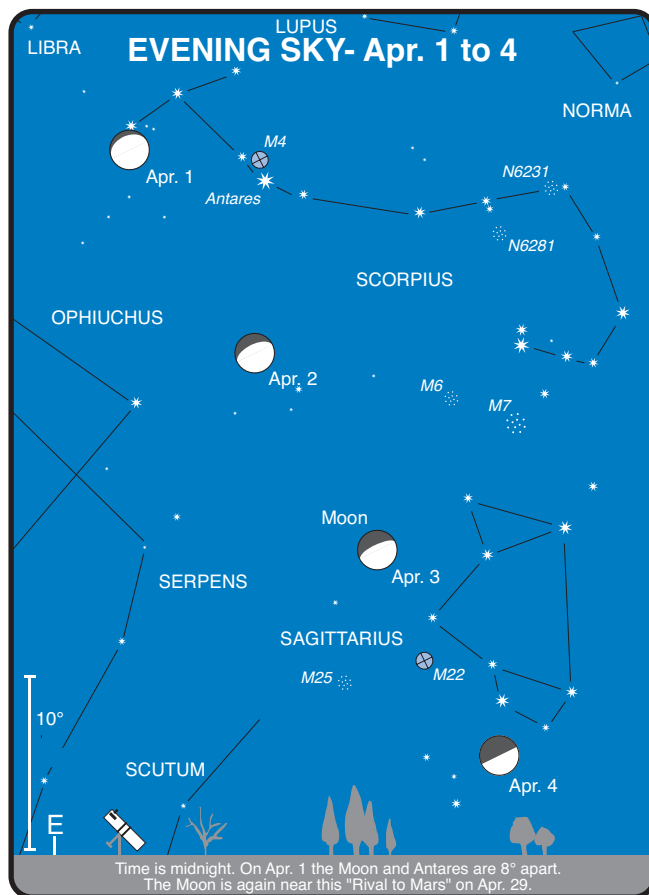


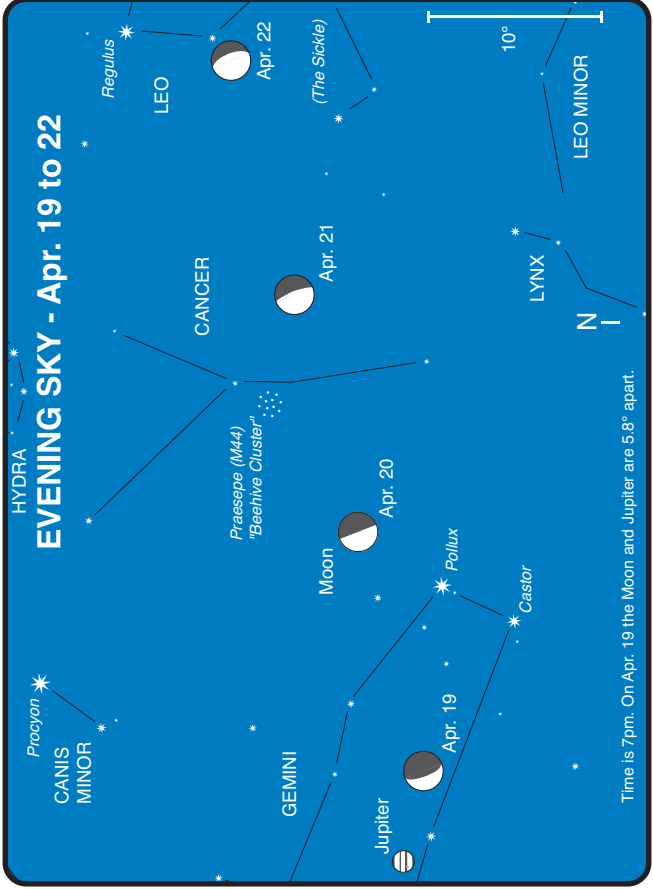
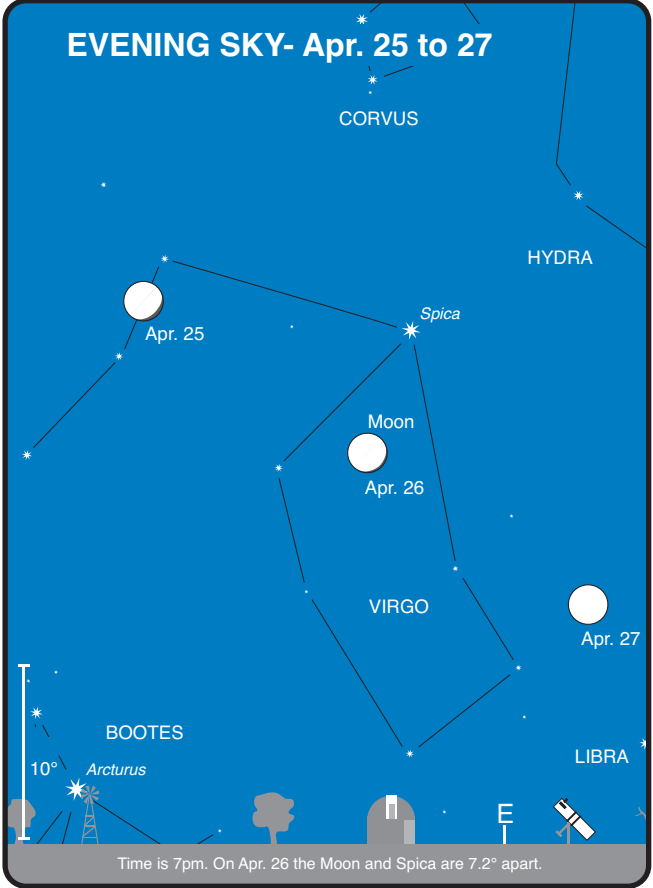
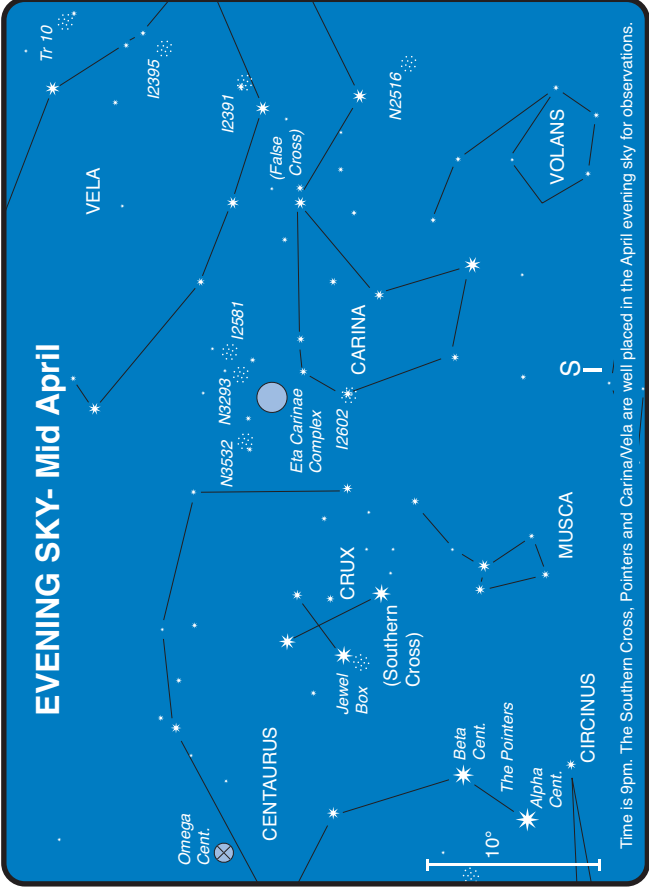
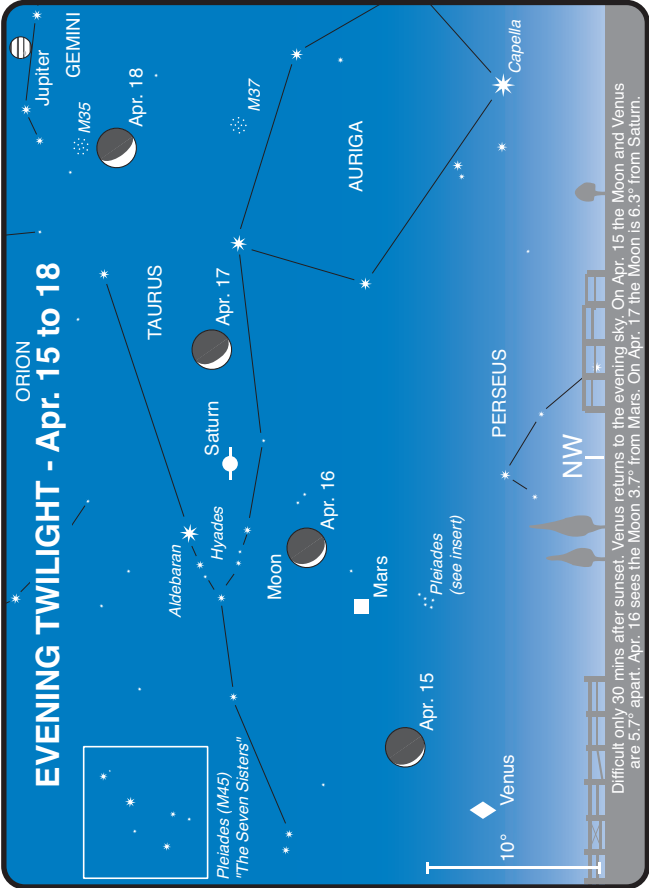
APRIL

The **pi Puppids** or **Grigg-Skjellerupids** (after the short period comet that produced the stream) is a very young southern shower first observed in 1972. They are best seen in the evening sky from 15th to 28th April, with maximum activity on the 23rd. Leading up to and after the maximum the rates are low and difficult to separate from sporadic meteors. The peak can vary greatly in intensity, sometimes nil and occasionally 3 to 4 per hour or more (13 in 1983, 40 in 1982 and 1977). The pi Puppids are noted for their very slow speed, brightness, persistent trains, and large proportion of yellow meteors and occasional fireballs.

DIARY

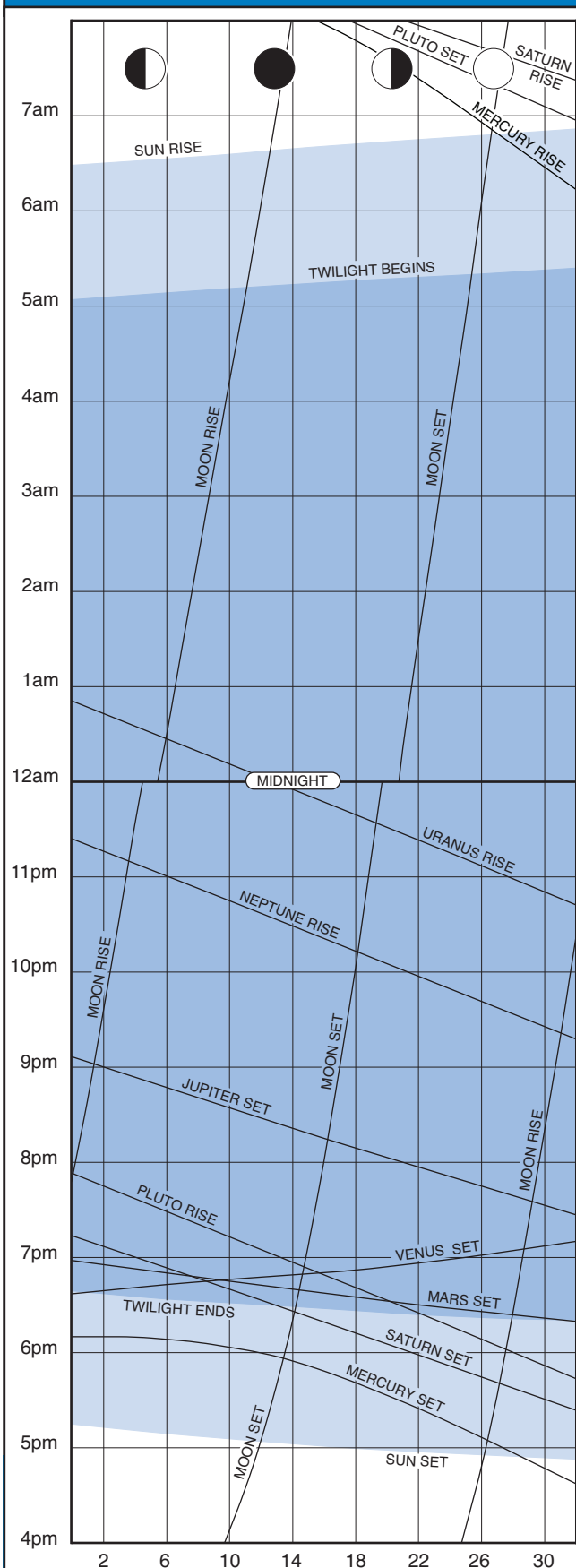
1st	2 AM	Saturn 4°N of Aldebaran
3rd	3 AM	m.p. 6 Hebe 0.7°NW of M26 (OC) in Scutum
4th	3 AM	Comet C/2000 WM1 (LINEAR) 0.5°E of NGC 6755 (OC) in Aquila
4th	Midnight	Comet 57P/du Toit-Neujmin-Delporte 0.9°S of M25 (OC) in Sagittarius
5th	1:29 AM	Last Quarter Moon
7th	2 AM	Neptune 4°N of Moon
7th	7 PM	Mercury in superior conjunction
8th	11 AM	Uranus 4°N of Moon
9th	4 AM	Comet 7P/Pons-Winnecke 0.1°W of NGC 6741 (PN) in Aquila
9th		m.p. 9 Metis 0.6°S of star Pollux
10th	3 PM	Moon at apogee
12th		Mercury at ascending node
12th		Mars 3.5°S of Pleiades M45 (OC) in Taurus
13th	2 AM	m.p. 6 Hebe 0.6°N of NGC 6712 (GC) in Scutum
13th	5:21 AM	New Moon
13th		Venus at ascending node
14th	1 AM	m.p. 25 Phocaea 0.5°SE of NGC 6539 (GC) in Serpens
15th	3 AM	Venus 3°N of Moon
16th	9 AM	Mars 2°N of Moon
17th	6 AM	Saturn 0.8°S of Moon; occultation
17th		Mercury at perihelion
17th	8 PM	Vesta 0.7°S of Moon; occultation
18th		m.p. 1 Ceres 1°N of NGC 7727 (SG) in Aquarius
19th	9 AM	Jupiter 1.6°S of Moon
20th	10:48 PM	First Quarter Moon
25th		Venus 3.6°S of the Pleiades (OC) in Taurus
26th	2 AM	Moon at perigee
27th		Mercury at greatest latitude North
27th	1:00 PM	Full Moon
29th		m.p. 4 Vesta 0.9°N of Crab Nebula (M1) in Taurus
29th	11 PM	Mars 6°N of Aldebaran
29th	Midnight	m.p. 25 Phocaea 0.6°W of star Eta Serpentis
30th		Mercury 1.5°S of the Pleiades (OC) in Taurus





MAY

RISE/SET CHART



All times are AEST.

MAY HIGHLIGHTS

- The Moon and the planets in the western evening sky provide several weeks of interesting conjunctions and configurations this month
- From May 5 to 11 Mercury, Venus, Saturn and Mars fit within a 10° circle.
- Mercury, Saturn and Aldebaran form an equilateral triangle
- Venus and Mars very close
- Penumbral Lunar Eclipse
- Jupiter and Venus close at month-end
- Mars passes by M35

THE MOON

- 4th Last Quarter
- 8th Moon at apogee (furthest from Earth – 405,483 km distant, angular size 29.7')
- 12th New Moon
- 14th Occultation of Saturn by the Moon, visible from parts of Northern Hemisphere
- 15th Occultation of Mars by the Moon, visible from parts of South America
- 15th Occultation of Venus by the Moon, visible from South Pacific Ocean
- 15th Occultation of minor planet Vesta by the Moon, visible from parts of Northern Hemisphere

APPEARANCE of the PLANETS

MERCURY

Mercury is in inferior conjunction on the 27th



4th May
Gt Eastern
Elongation
dia 7.91"
mag 0.3



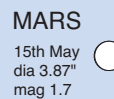
15th May
dia 10.44"
mag 1.7



25th May
dia 12.14"
mag 3.1

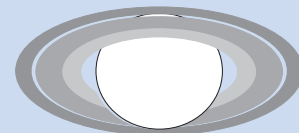


VENUS
15th May
dia 11.91"
mag -3.9



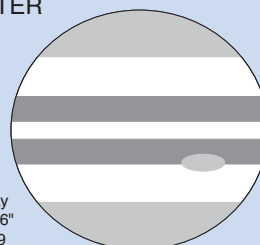
MARS
15th May
dia 3.87"
mag 1.7

SATURN



15th May
dia 16.65"
mag 0.1

JUPITER



15th May
dia 33.86"
mag -1.9

URANUS

15th May
dia 3.51"
mag 5.8

NEPTUNE

15th May
dia 2.29"
mag 7.9

PLUTO

15th May
dia 0.11"
mag 13.8

- 20th First Quarter
 24th Moon at perigee (closest to Earth – 364,984 km distant, angular size 32.9')
 26th Full Moon. Penumbral Lunar Eclipse, visible from Australia (see p. 83)

THE PLANETS

MERCURY reaches its greatest elongation east of the Sun (21°) on the 4th (see Sky View). This is not a particularly favourable elongation, with the planet remaining in the twilight sky and setting about an hour after the Sun during the first half of the month. Mercury then moves back toward the Sun and inferior conjunction (between Earth and Sun) on the 27th; before reappearing in the June morning sky. For a day or two either side of the 15th, Mercury, Saturn and Aldebaran form an equilateral triangle (see Sky View).

VENUS, low in the NW evening twilight, forms an equilateral triangle with Mars and Saturn on the 6th, with sides measuring

2.5°. On the 10th and 11th, Venus and Mars appear a close 0.4° apart (see Sky View). The 3-day old crescent Moon enters the picture on the 15th, 3.6° from Venus (see Sky View). Leaving Taurus in the last week of May, Venus moves into Gemini and on the 22nd comes within 0.7° from the heart of the open cluster M35. On the 23rd and 24th the asteroid Vesta (magnitude 8.4) is 1.5° from the planet. While Venus gains altitude as it moves toward its greatest elongation from the Sun in late August, it passes by Jupiter. At month-end, the two planets are 4° apart.

MARS and **SATURN**, low in the NW evening twilight, are less than 2.3° apart from the 3rd to the 5th (see Sky View). Mars and Venus appear close at 0.4° apart on the 10th and 11th (see Sky View). At the end of May, Mars follows Venus into Gemini, and on the 31st the Red Planet passes across the outer limits of the open star cluster M35. This is a rich star cluster composed of about 200 stars of magnitude 8 to 16. It is visible to the unaided eye under dark skies as a hazy patch, almost Moon sized.

COMET C/2001 A2 (LINEAR)

One year ago this month, the attention of Southern Hemisphere observers was drawn to the western evening sky where Comet C/2001 A2 (LINEAR) was putting on a spectacular display. This object was originally thought to be an asteroid when discovered in January 2001, by the Lincoln Near Earth Research (or LINEAR) programme* at a faint 15.8 magnitude. At the time, based on preliminary data, the IAU predicted the comet would not get any brighter than 10th magnitude.

By mid March, Comet C/2001 A2 was still only 13th magnitude but then underwent a series of rapid increases in brightness that had been likely caused by the comet fragmenting. Around March 26, observers started to report a brightening and an increase in size. In only four days the comet jumped by around 5 magnitudes! By the end of April the comet had reached 6th magnitude. In May, its first split, now showing a double nucleus, was clearly visible in amateur equipment, such as on Quasar Observatory's 25cm LX200 and ST6 CCD

Asteroid

camera. May 11 saw a further outburst with another break-up being detected. The remainder of the month saw the comet at 4th magnitude with a bright naked eye coma (as seen from dark, country skies). An obvious tail, stretching to 4 degrees in length, clearly visible in the smallest

was binoculars. The coma was a distinctive triangular shape, green in colour.

The comet maintained this display as it rapidly passed through perihelion and appeared in the morning sky in early June. C/2001 A2 continued to break-up. By mid June six fragments had now been detected, which had been under close scrutiny by observers including Australian Gordon Garradd, who took the spectacular image on this page. During July some minor outbursts were reported that may have been connected to short-lived splinters. The end of July saw the comet fade to 7th magnitude as it continued to leave the inner solar system.

C/2001 A2
 (LINEAR) May
 22.342UT, 2001. 60 sec
 exposures of coma and tail
 combined into a mosaic,
 showing over a degree of tail.
 Taken with a 45cm f/5.4
 Newtonian + AP7 CCD
 camera. Gordon Garradd,
 Loomberah NSW

* LINEAR is a joint cooperation between the American Air Force and MIT's Lincoln Laboratory which operate 2 X one-meter aperture GEODSS telescopes, which have been fitted with the latest CCD technology, to search for asteroids which may come close to the Earth.

MAY

JUPITER in Gemini, is slightly removed from the events happening in neighbouring Taurus (see above), but nonetheless forms a part of the overall picture. On the 16th, the 4-day old crescent Moon is located 4° below Jupiter (see Sky View). Jupiter and Venus appear 4° from each other at the end of May, the brilliance of the two planets making a striking sight in the early evening sky.

URANUS and **NEPTUNE** now rise before midnight mid month. On the early morning of the 4th, the 22-day old Moon is 6° from Neptune and on the morning of the 6th, the Moon is 4.5° from Uranus.

PLUTO rises around 7pm mid-month and is visible most of the month. This distant world is at opposition early next month.

COMETS

Comet 7P/Pons-Winnecke reaches its peak brightness of around 11th magnitude this month. The comet also reaches perihelion on the 15th at 1.3 AU from the Sun. Pons-Winnecke moves through Aquila, Aquarius, Capricornus, and back into Aquarius again, and is rising before midnight. In late May, the comet is less than a degree from Uranus.

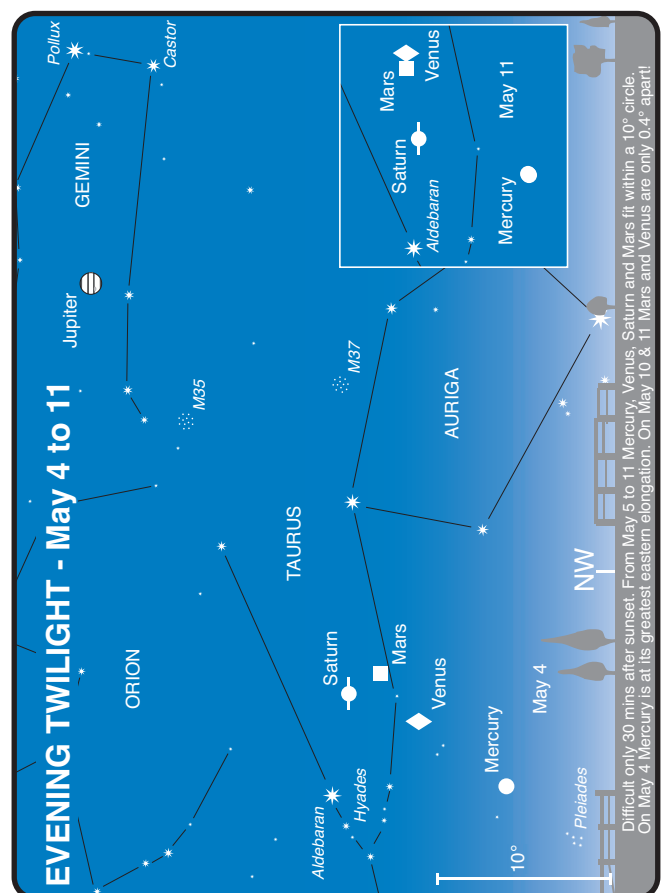
Comet P/1992 Q1 (Brewington), brightening from 14th to 13th magnitude, rises late in the evening. The comet can be found all month in the constellation of Microscopium. At the beginning of the month, Brewington is about a degree from 5th magnitude Alpha Microscopii.

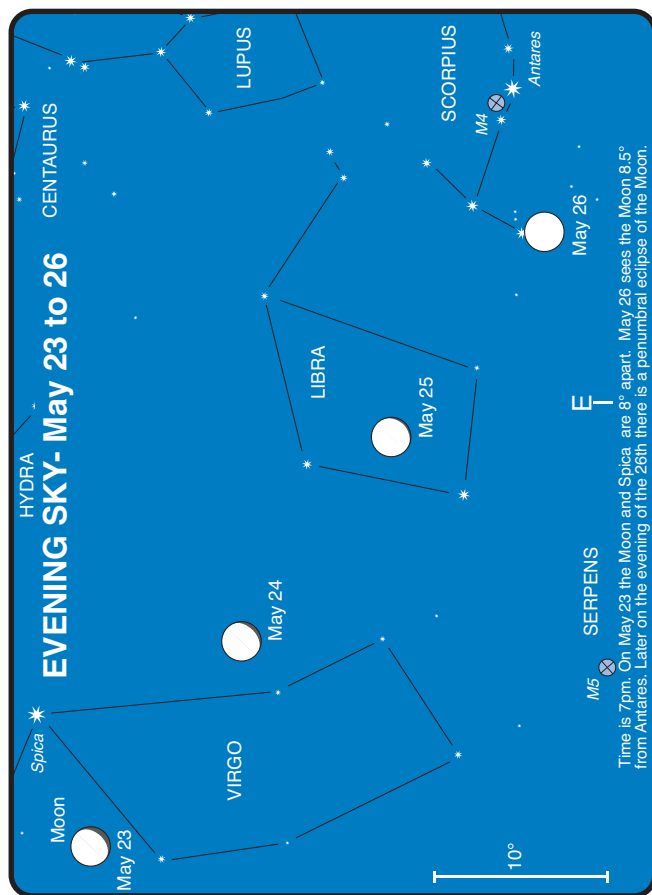
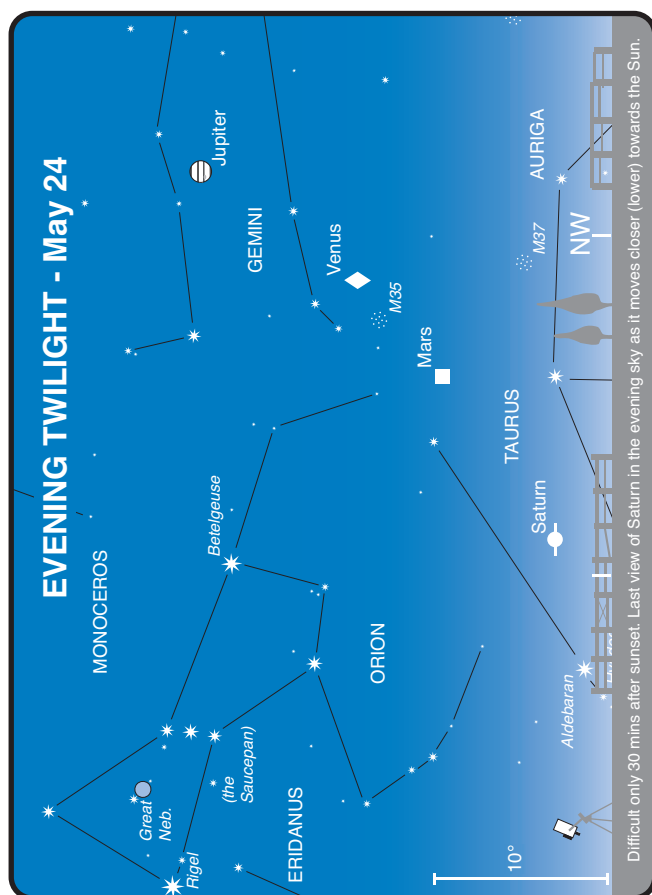
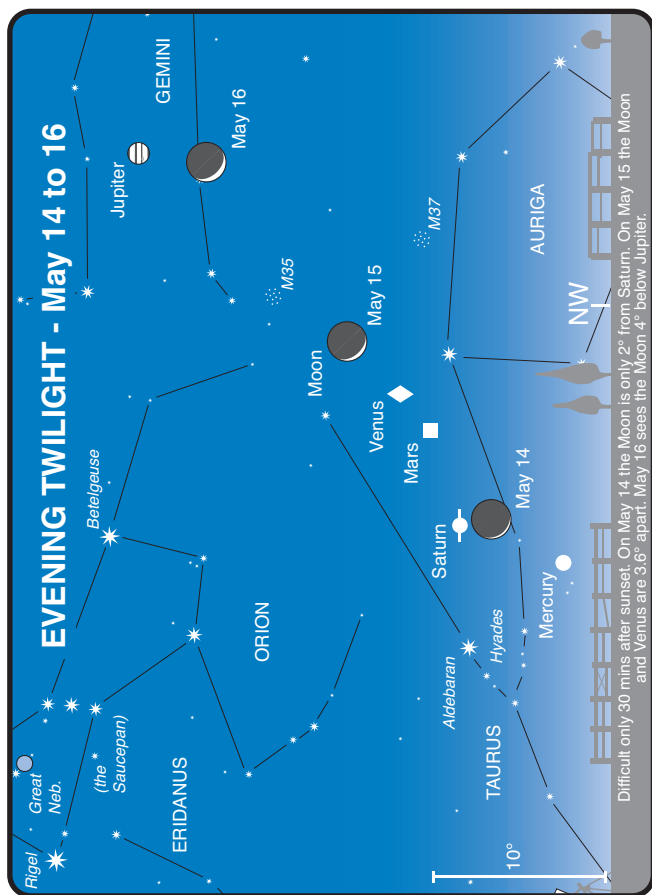
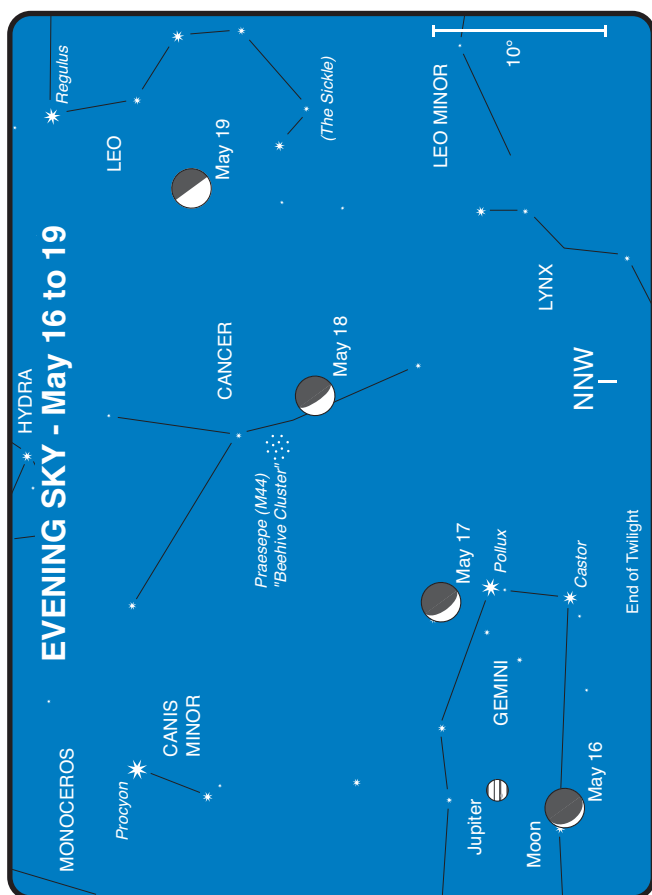
Comet C/2000 WM1 (LINEAR) spends May moving through the constellation of Hercules, rising late in the evening. The comet is expected to fade in brightness from 11th to 12th magnitude during the month. On 10th May, LINEAR is less than a degree from 4th magnitude Omicron Herculis.

DIARY

4th	10 AM	Neptune 4°N of Moon
4th	2 PM	Mercury greatest elongation E (21°)
4th	5:16 PM	Last Quarter Moon
4th	Midnight	Venus 6°N of Aldebaran
5th	3 AM	Mars 2°N of Saturn
5th	8 PM	Uranus 4°N of Moon
8th	4 AM	Venus 2°N of Saturn
8th	5 AM	Moon at apogee
9th		Mars 0.2°SE of NGC 1746 (OC) in Taurus
9th		Venus 0.6°W of NGC 1746 (OC) in Taurus
11th	7 AM	Venus 0.3°N of Mars
12th		m.p. 15 Eunomia 0.9°NE of m.p. 18 Melpomene
12th		m.p. 20 Massalia 0.5°S of NGC 524 (EG) in Pisces
12th	8:45 PM	New Moon
13th	Midnight	Neptune stationary
14th	7 AM	Mercury 3°N of Moon
14th		m.p. 4 Vesta 0.2°NW of NGC 2129 (OC) in Gemini
14th	6 PM	Saturn 1.1°S of Moon; occultation
15th	5 AM	Mars 0.6°N of Moon; occultation
15th	9 AM	Venus 0.8°N of Moon; occultation
15th	10 PM	Vesta 1.1°S of Moon; occultation
16th	3 PM	Mercury stationary
16th	10 PM	Jupiter 2°S of Moon
17th		Venus at perihelion
17th		m.p. 8 Flora 0.5°N of m.p. 28 Bellona

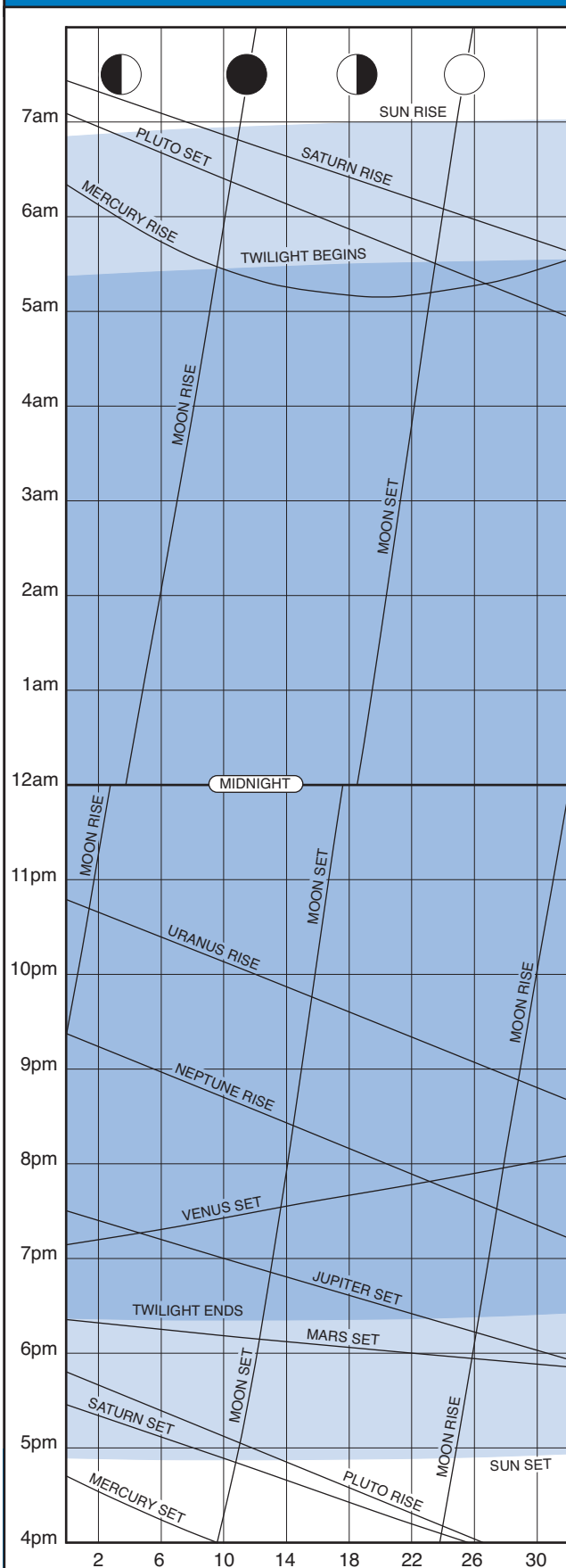
19th		m.p. 4 Vesta 0.8°S of M35 (OC) in Gemini
20th	5:42 AM	First Quarter Moon
20th		m.p. 5 Astraea 0.1°SW of NGC 4887 (SG) in Pisces
21st		Mercury at descending node
22nd		m.p. 44 Nysa 0.8°NW of NGC 488 (SG) in Pisces
22nd		Venus 0.7°N of M35 (OC) in Gemini
24th	2 AM	Moon at perigee
25th		m.p. 4 Vesta 0.3°N of IC 444 (Bright Neb) in Gemini
26th	9:51 PM	Full Moon; penumbral eclipse
27th	3 AM	Comet 7P/Pons-Winnecke 1°SW of Uranus
27th	5 PM	Mercury in inferior conjunction
30th		Mars 0.4°N of IC 2157 (OC) in Gemini
31st		Mercury at aphelion
31st		Mars 0.1°NW of M35 (OC) in Gemini
31st	6 PM	Neptune 4°N of Moon





JUNE

RISE/SET CHART



All times are AEST.

JUNE HIGHLIGHTS

- Mercury near Aldebaran
- Mercury and Saturn close at end of month
- Venus and Jupiter close in the evening sky
- Venus passes near M44
- Pluto at opposition
- Partial eclipse of the Sun, visible from northern Australia

THE MOON

- 3rd Last Quarter
- 4th Moon at apogee (furthest from Earth – 404,522 km distant, angular size 29.4')
- 11th New Moon. Annular Eclipse of the Sun, visible from the Pacific Ocean (see p. 83). Partial phase can be seen from Northern Territory and far north Queensland.
- 12th Occultation of Mars by the Moon, visible from parts of Northern Hemisphere
- 18th First Quarter
- 19th Moon at perigee (closest to Earth – 369,309 km distant, angular size 32.8')
- 25th Full Moon. Penumbral Lunar Eclipse, technically not visible (see p. 83)

THE PLANETS

MERCURY moves to the west of the Sun after inferior conjunction late last month, returning to the morning sky. Best viewed after the first week of June, the planet reaches its greatest elongation west of the Sun on the 22nd (23°). On the 23rd and 24th Mercury will be less than 2.5° from the 1st magnitude star Aldebaran (see Sky View). At the end of the month, this speedy little planet will be found 3.7° from the rising Saturn.

APPEARANCE of the PLANETS

MERCURY



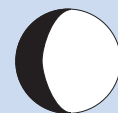
5th Jun
dia 11.52"
mag 2.2



15th Jun
dia 9.48"
mag 1.3



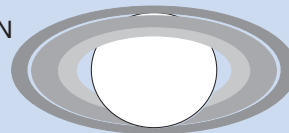
22nd Jun
Gt Western
Elongation
dia 8.24"
mag 0.6



VENUS
15th Jun
dia 13.81"
mag -4.0

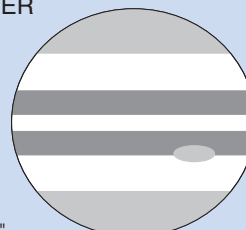
MARS
15th Jun
dia 3.66"
mag 1.7

SATURN



15th Jun
dia 16.52"
mag 0.0

JUPITER



15th Jun
dia 32.17"
mag -1.8

URANUS
15th Jun
dia 3.60"
mag 5.8

NEPTUNE
15th Jun
dia 2.32"
mag 7.9

PLUTO
7th Jun
Opposition
dia 0.11"
mag 13.8

VENUS begins the month 4° below Jupiter in Gemini, rising up in the NW evening sky. It moves into Cancer mid-month and finally over to Leo at month-end. From the 3rd to the 5th, the two brightest planets will be less than 2° from each other, a magnificent sight in the evening sky (see Sky View). The 3-day old crescent Moon will be 5° from the planet on the 14th (see Sky View). On the 21st, Venus will be within 0.5° from the famous M44, the Beehive or Praesepe. M44 is a cluster of about 200 stars, 80 or so of the brightest are visible in small telescopes. At 3rd magnitude the cluster is easily visible to the unaided eye from dark skies. In fact it is collectively brighter than any of the stars that make up the constellation of Cancer!

EARTH, at Solstice on the 21st, marks when the Southern Hemisphere days are shortest. On this day at noon, the Sun is at its most northerly position with a declination of $+23.5^\circ$.

MARS, in Gemini, now sets about an hour after the Sun and is no longer visible outside of the twilight glow. The Red Planet is moving slowly toward inferior conjunction in August. On the 30th, a good unobstructed western horizon will reveal Mars 1.6° below Jupiter in the twilight.

JUPITER is low in the NW evening twilight sky. Along with Venus, Castor and Pollux it forms a lopsided rectangle in Gemini on the 1st of the month. On the 13th, the 2-day old thin crescent

PROXIMA CENTAURI

High in the early evening sky this month lies the spectacular constellation of Centaurus, wrapped around the Southern Cross and partly lying along bright and dark rifts of the Milky Way. Within its boundary lies nine stars brighter than 3rd magnitude, two well known galaxies (Centaurus A and NGC4945), arguably the best globular cluster in the sky (Omega Centauri) and a particular 10.7 magnitude star. Did I hear someone say 'what?' Well this star is certainly ordinary, by probably any astronomer's definition, except that it has the distinction of being the closest star to our Solar System - Proxima Centauri.

Everyone who has looked through a telescope has seen the brilliant double star Alpha Centauri. This is in fact a true binary, with the two components orbiting each other in an eccentric orbit every 80 years. Alpha is in fact a triple star with its much more distant, faint companion being Proxima. It is located approximately 2° SW of Alpha and a little closer to us than its much brighter brothers. It was discovered by measurements of its proper motion by R.T. Innes in 1915. The star is believed to be gravitationally linked to Alpha Centauri but 400 times further away than the mean separation of the main pair and taking some 500,000 to a million years (depending on which reference you quote) to complete one orbit. Proxima's distance from Alpha is approximately 10,000 times greater than the distance from the Earth to the Sun (about $1/6$ of a light year). Innes measured the parallax as $0.762''$ and the annual proper motion of $3.85''$, both values being slightly larger (hence closer) than Alpha. The proper motions of Proxima and Alpha are moving them westward towards the companion pointer, Beta. In fact, Alpha will make its closest approach to Beta around 6200AD when it will be $23'$ north - less than the diameter of the Moon away! At this time, Beta will actually pass between Alpha and the distant Proxima.

Being so close and faint it comes as no surprise to learn it is one of the least luminous stars ever found. Its absolute magnitude is only $+15.1$ and its real luminosity is 13,000 times less than the Sun. It is a little ironic that, with all the thousands of naked eye stars in the heavens, a small telescope and a good finder chart is needed to see the closest star of them all (excluding the Sun). If it replaced the Sun it would only be as bright as 45 Full Moons and about $1/20$ of its diameter.

Probably the most interesting aspect of Proxima is that this red dwarf (spectral class dM5e) is also a flare star. It can increase in brightness by up to a magnitude in only a few minutes. These temporary flashes occur at irregular intervals and the star returns to its normal brightness in less than 30 minutes. Harlow Sharpley, studying Harvard plates, detected 48 flares during the interval of 1925 to 1950. Back in the 60's a number of Australian amateurs took part in a program to monitor Proxima for flares.

For such an insignificant star, on the galactic scale, Proxima certainly holds a special place in our knowledge of our stellar neighbourhood.

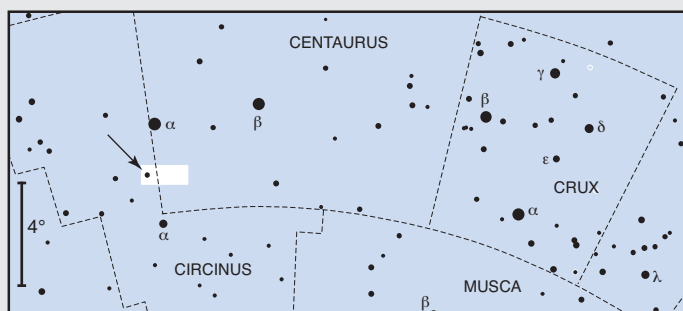


Chart 1. Locate the 5th magnitude star (arrowed) mid-way between Alpha Centauri and Alpha Circini. Faintest stars shown are approximately 6th magnitude. The white block represents the area covered below in chart 2.

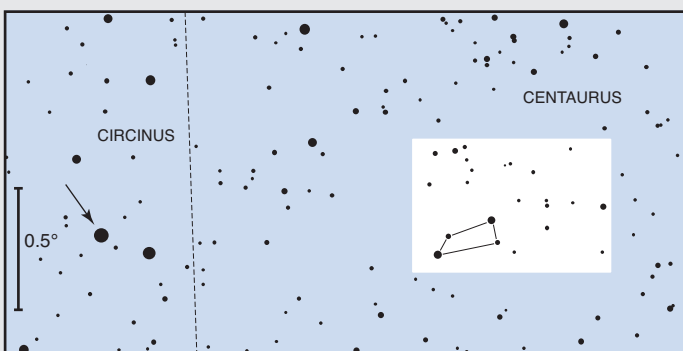


Chart 2. From the 5th magnitude star (arrowed), track west just under 2° to a trapezium made up of 8th and 9th magnitude stars. The faintest stars shown are approximately 10.5 magnitude. The white block represents the area covered below in chart 3.

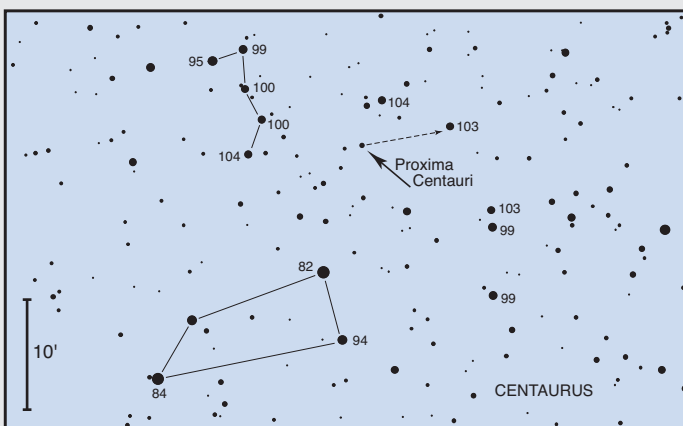


Chart 3. From the trapezium, it is easy to star-hop to Proxima. Another prominent landmark in the field is the 'W' of 9 and 10th magnitude stars. Numbers next to stars are the magnitudes (104 = 10.4 magnitude). Stars are shown down to approximately 13th magnitude. The dashed arrow extending from Proxima shows the direction and distance that proper motion will take the star over the next 100 years.

JUNE

Moon appears 3.4° from the planet (see Sky View). From the 9th to the 11th, Jupiter will be less than 0.5° from a 3.5 magnitude star known as Wasat or Delta Geminorum. The significance of Delta Gem is that it was the guide star that Clyde Tombaugh centred his telescope on 72 years ago, when taking the discovery plates of Pluto. Jupiter at this time is very close to the original discovery position of the most distant planet.

SATURN is lost from the evening sky when it moves into solar conjunction on the 9th, returning to the morning twilight towards the end of the month. During the last week of June, Saturn and Mercury approach each other, and early next month the pair have a close rendezvous.

URANUS and **NEPTUNE** both rise in the mid-evening. Mid-morning on the 2nd, the 21-day old Moon is 5° from Uranus. The Moon is within 5° of Neptune on the early mornings of the 1st and 28th.

PLUTO is at opposition on the 7th, and is visible the entire night. Our most distant planet is currently 4,416,000,000 km from Earth, with its light taking a little over 4 hours to reach us.

MINOR PLANETS at opposition this month include 6 Hebe on the 30th at magnitude 8.9 in Scutum and 25 Phocaea on the 23rd at magnitude 10.0 in Hercules. 8 Flora and 28 Bellona visit the Leo group of galaxies in June.

COMETS

Comet 7P/Pons-Winnecke can be found moving through Aquarius and Sculptor this month. The 11th magnitude comet is rising before midnight and is visible until dawn. Early in the month, Pons-Winnecke is at its closest to Earth (0.63 AU) during this apparition.

Comet 46P/Wirtanen should become visible in large telescopes this month as it brightens from 15th to 13th magnitude. Located in the pre-dawn sky, Wirtanen spends the bulk of the month in Cetus before crossing over into neighbouring Taurus.

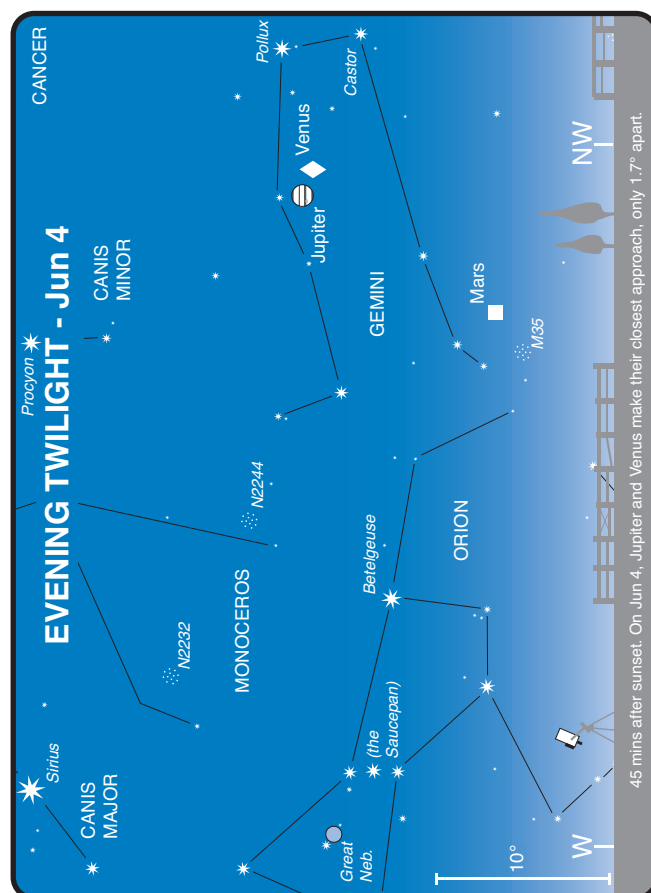
Comet P/1992 Q1 (Brewington) spends the entire month in the constellation of Microscopium. Brewington rises early in the evening and is visible all night. During the month, the comet should brighten from 13th to 12th magnitude.

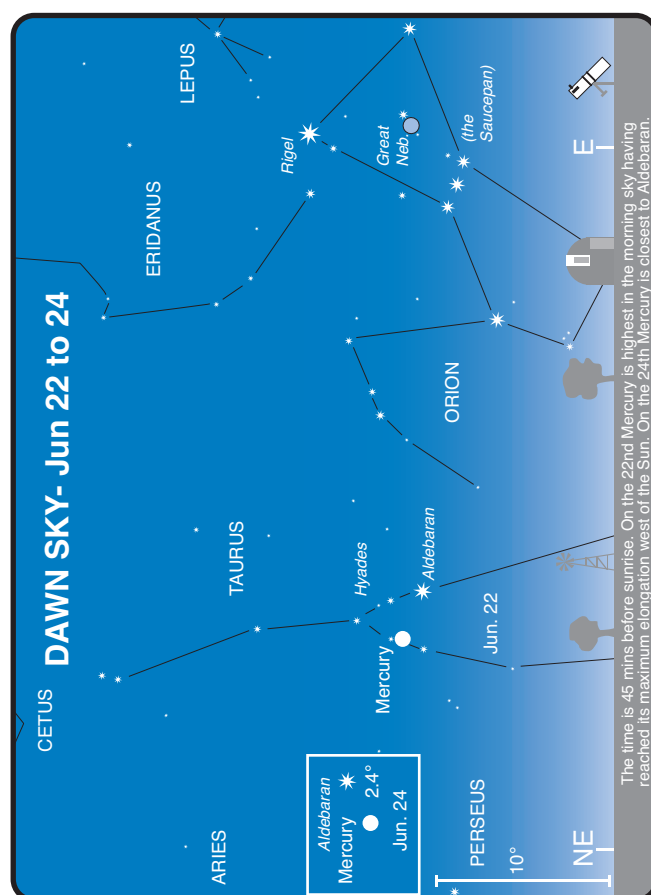
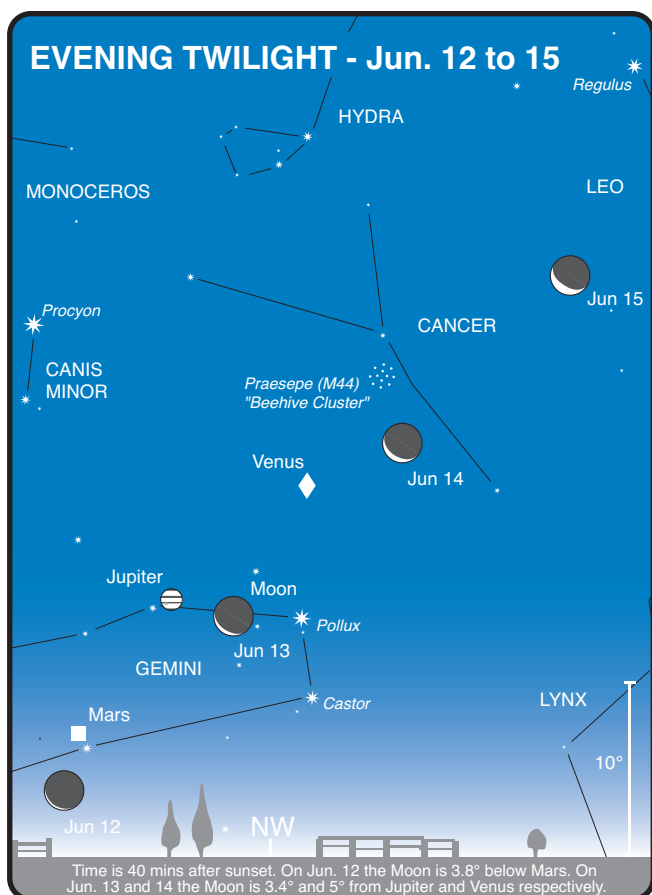
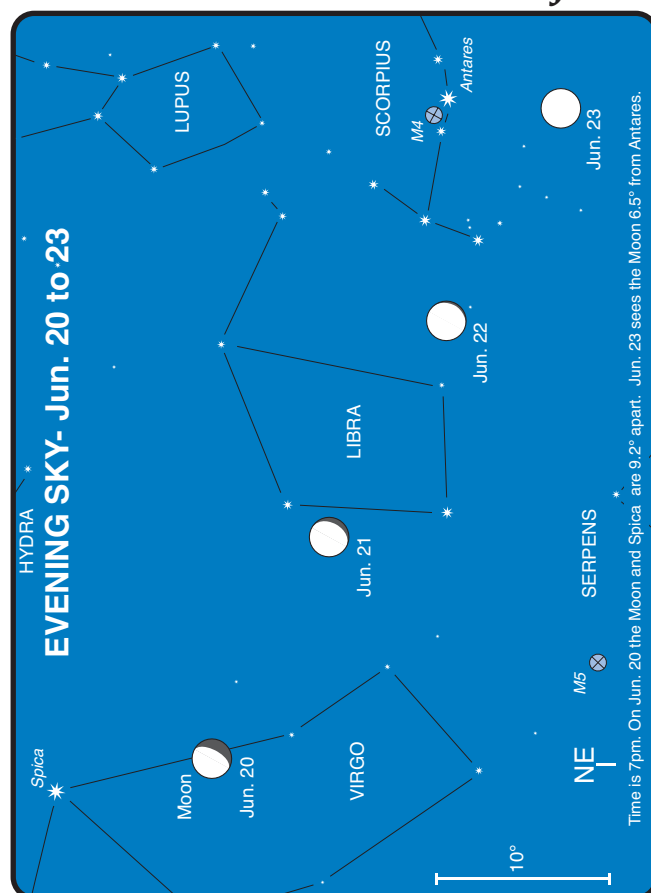
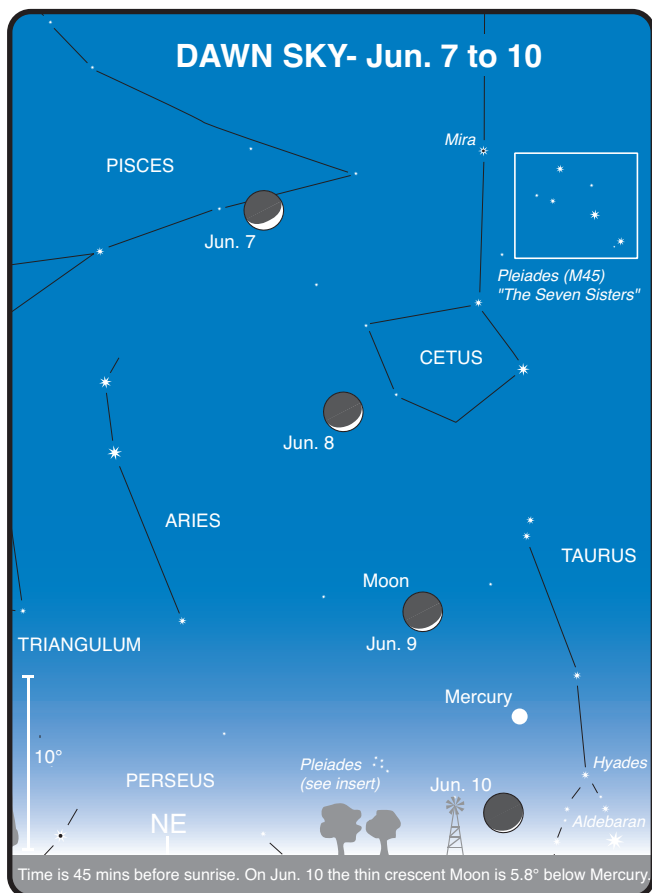
Comet C/2000 WM1 (LINEAR) begins June located midway between the 3rd magnitude stars Pi Herculis and 68 Herculis. On 18th June, LINEAR will be less than a degree from the globular cluster M13. By month's end, the comet has faded from 12th to 13th magnitude.

DIARY

1st		m.p. 5 Astraea 0.8°SE of m.p. 44 Nysa
2nd	4 AM	Uranus 4°N of Moon
3rd	10:05 AM	Last Quarter Moon
3rd	5 PM	Uranus stationary
4th	4 AM	Venus 1.6°N of Jupiter
4th	11 PM	Moon at apogee
6th		m.p. 8 Flora 0.5°N of NGC 3338 (SG) in Leo
7th	3 PM	Pluto at opposition
8th		Venus at greatest latitude North
8th	9 PM	Mercury stationary
8th	9 PM	m.p. 28 Bellona 0.1°S of NGC 3377 (EG) in Leo
9th	9 AM	Pallas stationary
9th	9 PM	Saturn in conjunction with Sun
9th	Midnight	Mercury 3°S of Moon
10th	6 AM	Venus 5°S of Pollux
10th		Jupiter 0.4°N of star Delta Geminorum
10th		m.p. 8 Flora 0.3°S of NGC 3377 (EG) in Leo
11th	9:46 AM	New Moon; eclipse
11th	9 PM	m.p. 28 Bellona 0.2°NE of NGC 3412 (EG) in Leo
12th		m.p. 3 Juno 0.6°SW of star Regulus

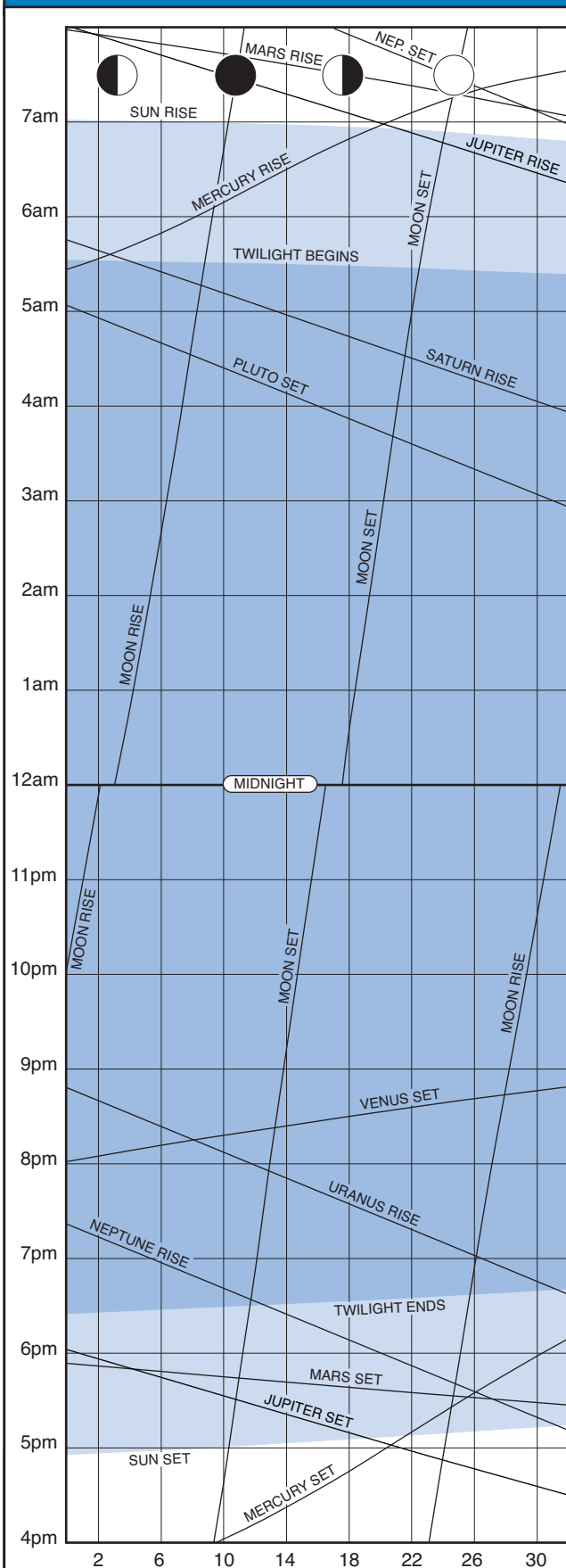
12th	10 PM	Mars 0.9°S of Moon; occultation
13th		m.p. 8 Flora 0.1°S of NGC 3412 (EG) in Leo
13th	2 PM	Jupiter 2°S of Moon
14th	7 AM	Venus 1.5°S of Moon
14th		m.p. 654 Zelinda 0.2°S of NGC 2974 (SG) in Sextans
17th	9 PM	m.p. 6 Hebe 0.4°N of M11 (OC) in Scutum
18th	10:29 AM	First Quarter Moon
18th	10 PM	Comet C/2000 WM1 (LINEAR) 0.3°S of M13 (GC) in Hercules
19th	5 PM	Moon at perigee
20th		Mercury at greatest latitude South
21st		Venus 0.6°NE of Beehive Cluster M44 (OC) in Cancer
21st	11 PM	Solstice
22nd	1 AM	Mercury greatest elongation W (23°)
22nd		m.p. 44 Nysa 1°S of NGC 821 (EG) in Aries
24th	2 PM	Mercury 2°N of Aldebaran
25th	7:42 AM	Full Moon; penumbral eclipse
26th		Mercury 0.7°NW of NGC 1647 (OC) in Taurus
28th	2 AM	Neptune 4°N of Moon
29th	Noon	Uranus 4°N of Moon





JULY

RISE/SET CHART



All times are AEST.

JULY HIGHLIGHTS

- Mercury and Saturn very close in dawn sky
- Venus near Regulus
- Venus close to minor planet Juno
- Saturn very near the Crab Nebula (M1)

THE MOON

- 2nd Moon at apogee (furthest from Earth – 404,210 km distant, angular size 29.2')
- 3rd Last Quarter
- 10th New Moon
- 14th Moon at perigee (closest to Earth – 367,847 km distant, angular size 32.3')
- 17th First Quarter
- 24th Full Moon
- 30th Moon at apogee (furthest from Earth – 404,743 km distant, angular size 29.4')

THE PLANETS

MERCURY is visible in the morning twilight early in July, the planet then moves back toward the Sun and superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 21st. It then reappears in the evening sky late in the month. Mercury and Saturn appear close early in the month, at their nearest on the 3rd at 0.5° apart (see Sky View).

VENUS, residing in the constellation of Leo during the month, is very conspicuous in the western evening sky. Between the 8th

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 21st

5th Jul
dia 6.04"
mag -0.7

15th Jul
dia 5.22"
mag -1.6

25th Jul
dia 5.02"
mag -1.6

VENUS

5th Jul
dia 15.68"
mag -4.1

15th Jul
dia 19.22"
mag -1.9

MARS

15th Jul
dia 3.55"
mag 1.8

SATURN

15th Jul
dia 16.76"
mag 0.1

URANUS

15th Jul
dia 3.68"
mag 5.7

JUPITER

15th Jul
dia 31.51"
mag -1.8

NEPTUNE

15th Jul
dia 2.35"
mag 7.8

PLUTO

15th Jul
dia 0.11"
mag 13.8

and the 13th the planet will be within 3° of the 1st magnitude star Regulus (Alpha Leonis); closest approach of 1.1° occurs on the 10th and 11th. On the 13th, the 3-day old Moon is 5° from Venus, the pair forming a triangle with Regulus (see Sky View).

The **EARTH** is at aphelion (the furthestmost point in its orbit from the Sun) on the 6th. The Earth/Sun distance is 1.016688 astronomical units, which is equivalent to about 152,096,000 km.

MARS can be seen early in the month in the evening twilight, but comes too close to the Sun for observation by mid-month.

Between the 2nd and 5th Mars and Jupiter are less than 1° apart. You will need a good unobstructed western horizon to see the pair as they are only 3° above the horizon 30 minutes after sunset.

JUPITER makes a last show in the evening twilight with the Red Planet (see Mars). Jupiter will be in conjunction with the Sun on the 20th, returning to the morning sky in mid-August.

SATURN rises around 5am mid-month in Taurus. Saturn and Mercury appear close early in the month, at their nearest on the 3rd at 0.5° (see Sky View). The thin waning crescent Moon appears 5.2° below the ringed planet on the 9th (see Sky View). In the latter part of the month, Saturn comes very close to the Crab Nebula. First in Messier's catalogue, the Crab Nebula or M1 is the remnant of the supernova of 1054AD. From the 21st to the 30th the planet will be less than 0.5° from M1, and on the 25th the pair are closest, at only 0.03° . M1 is a little closer to the planet than Saturn's moon Titan! If this visitation is beyond your normal observing hours, another very similar circumstance presents itself in the evening sky early next January.

URANUS and **NEPTUNE** in Aquarius and Capricornus respectively, rise in the early evening eastern sky. Both planets will be at opposition next month.

A Picture Worth A Thousand Stars – The Joys of 35mm Astrophotography

Glenn Dawes

Many people think that astrophotography is an expensive, specialist area. A hobby that soaks up as much money as you would like to throw at it. In some cases this is true but you may be amazed to learn what can be achieved with just a normal camera. I'm not just talking about breath-taking, wide-angle views of the Milky Way, but having the opportunity to make a real contribution to science!

What Equipment is needed? In the simplest case, all that you need is a second-hand 35mm camera with a fast lens, a cable release and a way to mount it. It is important that the camera have a manual 'B' setting to allow the shutter to be locked open with a cable release, without drawing on a lot of battery power to keep it open. The lens should be as fast as possible. A speed of $f/1.2$ to 1.8 would be ideal. Often lenses at this 'wide open' setting show poor star images in the corners. A star field is the most severe test for any optics. I have found that stopping these down to $f/2.8$ can sometimes help greatly without losing much speed.

A high-speed film is needed, at least 400 ASA. Fast modern films are much finer grained compared to their counterparts of the 70's and 80's. With this combination of camera, lens and film, mounted on a tripod, you can capture the brightest stars with a 30-second exposure. Beyond this the movement of the stars will cause trails. Star trails can also have their attractions. Sometimes it is difficult to get colours on the brightest stars because they can burnout. Letting them trail can show the colours quite well. Also wide angle (say 16mm lens) can be effectively used to patrol for fireball meteors, even though there are very long star trails over a couple of hours. To help avoid dew on the front of the lens it is a good idea to leave a neutral filter (such as a UV) and the sun hood on.

To go further we need to move the camera slowly to follow the stars, this is referred to as 'equatorial tracking'. Those who already have a telescope with an equatorial mount can mount the camera on the side of the telescope and let its drive follow the stars for you (while you have a coffee break).

A Photographic Patrol. Once you can guide the camera for say 5 to 10 minutes, a whole new world (Universe?) of discovery opens up. During the 80's and 90's I conducted a nova search programme in the southern Milky Way. In fact, it only takes around 20 fields with a 50mm lens, to cover all of the Milky Way regions visible from our mid-southern latitude. On a good, transparent night (out in the country) it was not unusual to get stars down to 11th magnitude. The programme consisted of taking photos of the sky and comparing them to identical images, taken some months before, looking for 'new' stars. With today's technology it is easy to enlist the help of a computer to help you search your photos. I recently experimented with

'Photoshop' to superimpose two scanned prints. Another method uses two slide projectors to merge the images on a screen and then 'blinking' one of them.

What can be Found? When searching the films it was rare to not find at least one variable star per field. Some of these soon became old friends as they were picked up on each cycle. This is especially the case if my favourite reference slide showed the star near a minimum. There is no shortage of relatively bright Mira type variables to re-discover or maybe a new variable? In fact, this technique led to my discovery of V854 Cen in 1986. A 'variable' which turned out to be the third brightest R Coronae Borealis star (but that's another story).

This technique is also well suited for finding minor planets. All of the minor planets, mentioned in this publication, should be easily within reach when they are near their brightest i.e., at opposition. The monthly sections even tell you the constellation they are in during opposition, so all that you need is a planisphere to help you point your camera. Two photos, a week apart, should be sufficient to see the asteroid move. Of course a nova is also not out of the question. Statistically, there should be one or two each year easily within reach of this set-up. If you are going searching always take two images of the field. This helps eliminate confusion from film or developing flaws. Good luck!



Southern Cross and Pointers. 50mm lens @ $f/2.8$. A 5 min exposure using Kodak T-Max 400. NB the dark nebula or the 'Coal Sack' (slightly below and left of the Cross). This is also the head of the 'Emu' (see p. 37).

JULY

PLUTO, just past opposition, is visible throughout the night until around 4am.

MINOR PLANETS at opposition this month include 29 Amphitrite on the 23rd at magnitude 9.4 in Sagittarius. Towards the end of July 9 Metis visits the M95, 96, 105 trio of galaxies in Leo.

COMETS

Comet 7P/Pons-Winnecke resides in the constellation of Sculptor throughout July. Rising late in the evening, the comet should fade from 11th to 12th magnitude by month's end. Towards the end of July, Pons-Winnecke lies midway between the galaxies NGC 55 and NGC 300.

Comet 22P/Kopff is well placed in the evening sky, brightening from 14th to 13th magnitude as it moves through the constellation of Virgo. Around mid-month, Kopff is two degrees from the 10th magnitude galaxy M61.

Comet 46P/Wirtanen can be found in the pre-dawn sky this month in the constellation of Taurus. Brightening from 13th to 11th magnitude, the comet will pass across the Hyades around mid-month, and will be close to Comet 67P/Churyumov-Gerasimenko. On the morning of the 15th, comet Wirtanen is close to Aldebaran.

Comet 67P/Churyumov-Gerasimenko brightens from 14th to 13th magnitude this month as it approaches perihelion in August. The comet is rising a few hours before dawn and spends all of July in Taurus. Around mid-month, Churyumov-Gerasimenko passes near the Hyades and Comet 46P/Wirtanen.

Comet P/1992 Q1 (Brewington) is visible all night throughout July at about 12th magnitude. The comet is in Microscopium throughout the month.

METEOR SHOWERS

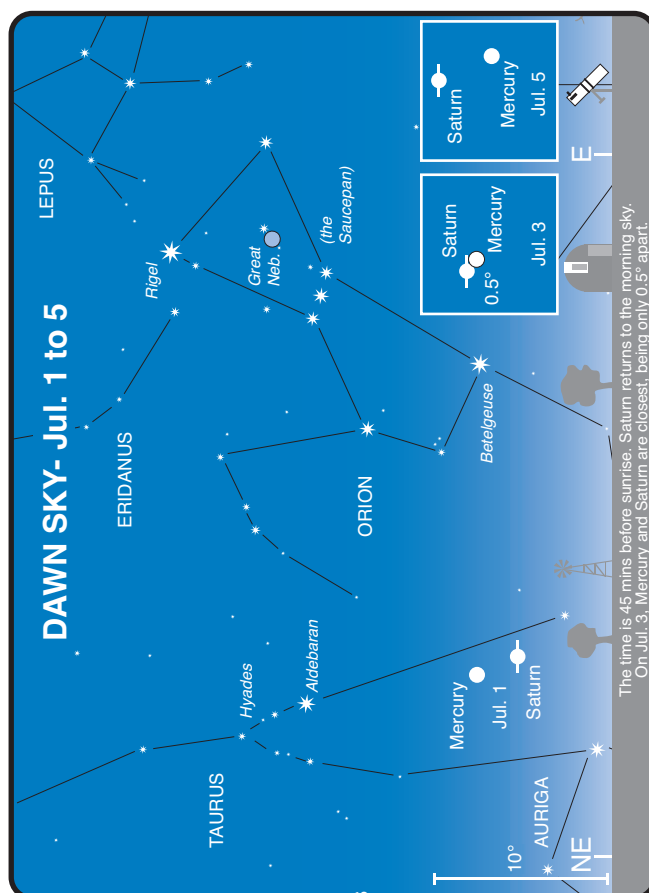
The **Pegasids** are a short-lived shower, lasting only from the 7th to 13th, with maximum on the 9th. The shower is best viewed during the second half of the night, and produces faint, swift meteors. The zenith hourly rate is low, and about 3 can be expected. The radiant is on the western side of the Great Square of Pegasus, near 3rd magnitude Alpha Pegasi.

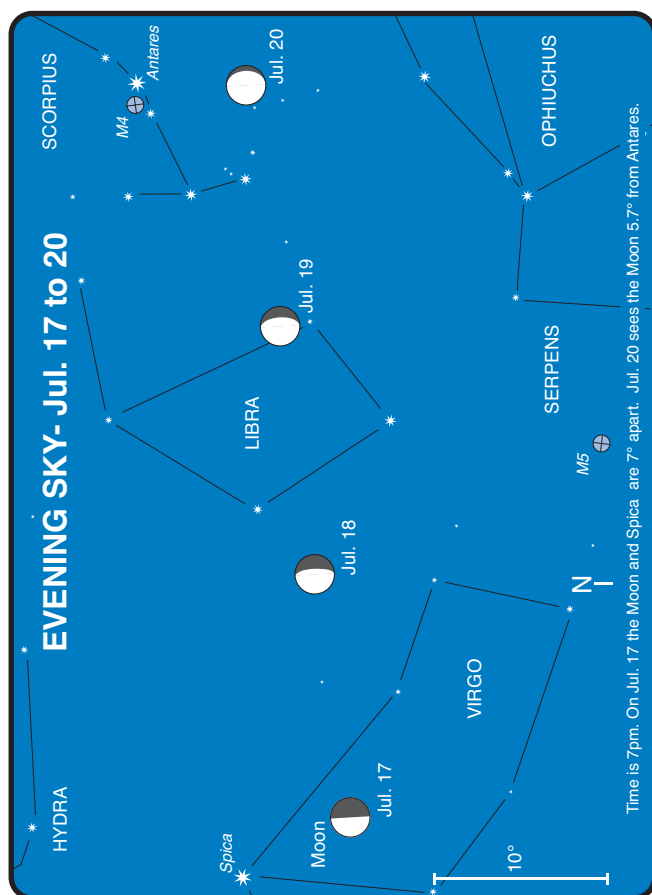
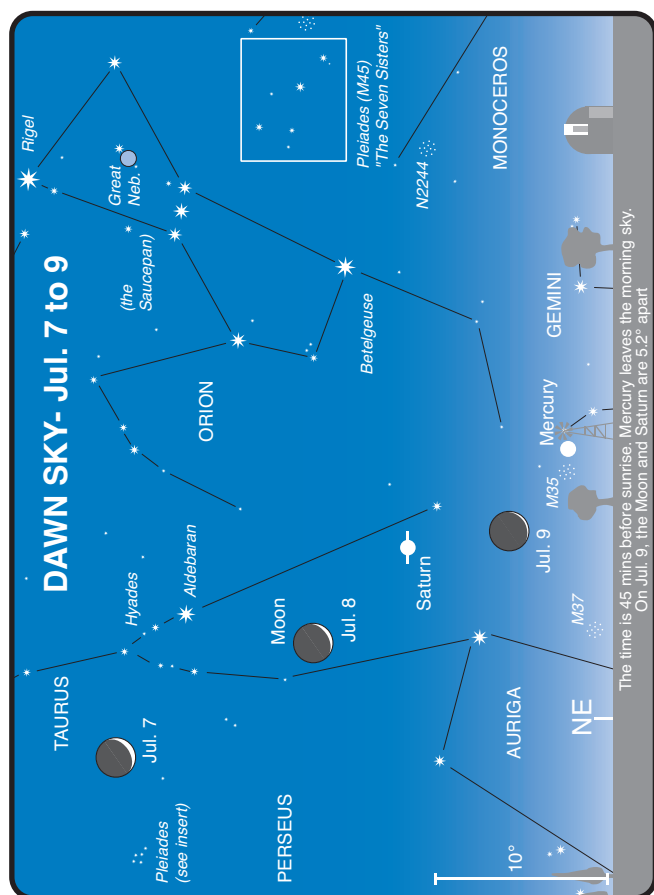
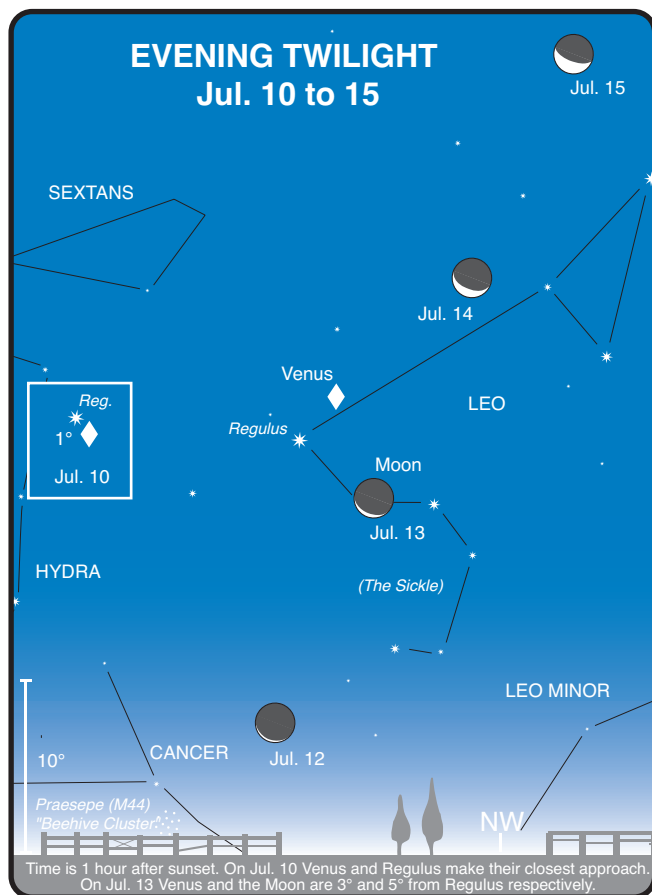
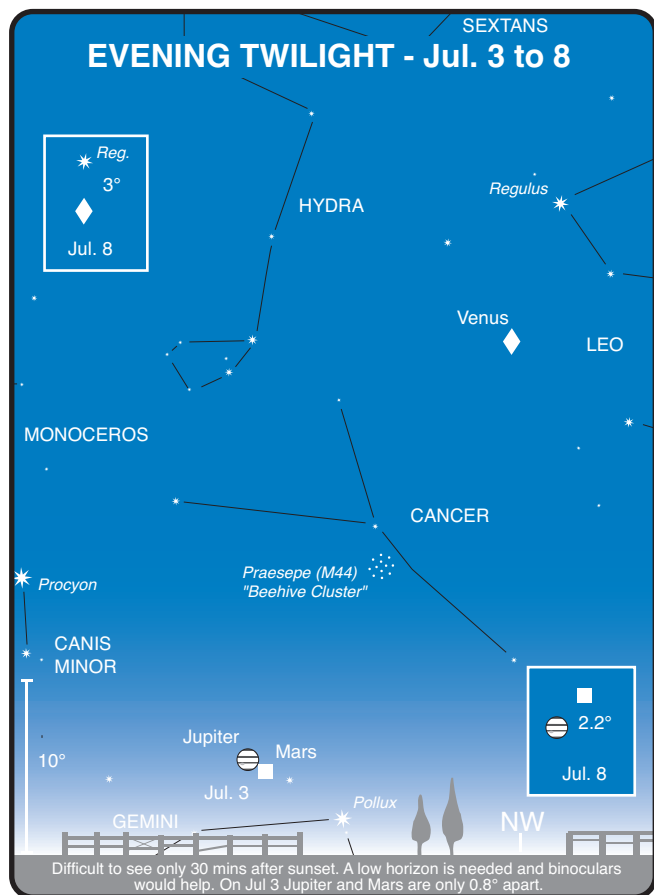
The **Phoenicids** (July) are a Southern Hemisphere shower, and are best seen after midnight until dawn, when the radiant is at its highest altitude. The Phoenicids are active from the 10th to 16th, with maximum on the 13th. Activity is variable, but zenith hourly rates of 3-10 have been recorded, although in more recent years the rate has been less than 4 per hour.

DIARY

2nd	6 PM	Moon at apogee
2nd	9 PM	Mercury 0.2°S of Saturn
3rd	3:19 AM	Last Quarter Moon
3rd	4 PM	Mars 0.8°N of Jupiter
4th		Mercury 0.4°W of M1 (neb) in Taurus
5th	3 AM	Mars 6°S of Pollux
5th	Midnight	Comet 7P/Pons-Winnecke 0.3°NE of Blanco 1 (OC) in Sculptor
6th	2 PM	Earth at aphelion
8th	11 PM	Saturn 1.7°S of Moon
9th		Mercury at ascending node
10th	8 PM	Venus 1.1°N of Regulus
10th	8:26 PM	New Moon
11th		m.p. 28 Bellona 0.4°N of NGC 3705 (SG) in Leo
13th		m.p. 8 Flora 0.5°SW of NGC 3705 (SG) in Leo
13th	10 PM	Venus 4°S of Moon

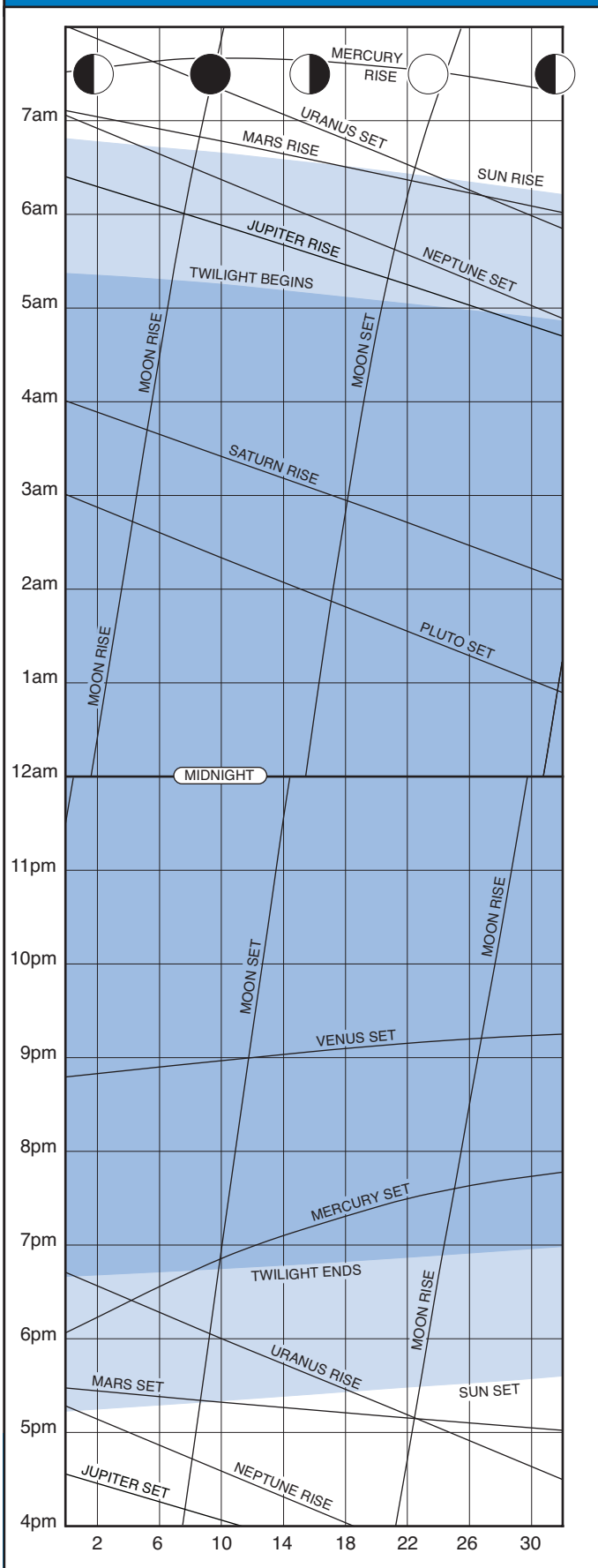
14th		Mercury at perihelion
14th	11 PM	Moon at perigee
16th	5 AM	Comet 46P/Wirtanen 0.7°S of Aldebaran
17th	2:47 PM	First Quarter Moon
20th		Venus 0.7°S of NGC 3429 (SG) in Leo
20th	11 AM	Jupiter in conjunction with Sun
21st	Noon	Mercury in superior conjunction
23rd		Venus 0.6°S of m.p. 3 Juno
23rd	6 PM	Vesta in conjunction with Sun
24th		Mercury at greatest latitude North
24th		Comet 46P/Wirtanen 1°N of NGC 1817 (OC) in Taurus
24th	7:07 PM	Full Moon
25th	9 AM	Neptune 4°N of Moon
25th		Saturn 0.03°N of Crab Nebula M1 (Neb) in Taurus
26th	7 PM	Uranus 4°N of Moon
29th		m.p. 9 Metis 0.6°SW of M105 (EG) in Leo
29th		m.p. 9 Metis 0.7°NE of M95 (SG) in Leo
30th		m.p. 9 Metis 0.3°NE of M96 (SG) in Leo
30th	Noon	Moon at apogee





AUGUST

RISE/SET CHART



AUGUST HIGHLIGHTS

- Mercury at its best for evening observation
- Mercury close to Regulus
- Venus at greatest elongation (46°) east of the Sun
- Venus and Spica close
- Jupiter close to M44
- Uranus at opposition
- Neptune at opposition

THE MOON

This month is unusual, it has five lunar phases (two Last Quarters)

- 1st Last Quarter
- 9th New Moon
- 11th Moon at perigee (closest to Earth – 362,927 km distant, angular size $33.0'$)
- 15th First Quarter
- 23rd Full Moon
- 27th Moon at apogee (furthest from Earth – 405,695 km distant, angular size $29.8'$)
- 31st Last Quarter

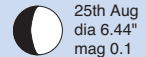
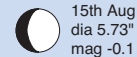
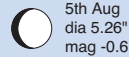
THE PLANETS

MERCURY will be its best for evening observation this year between mid-August and mid-September, reaching its greatest eastern elongation early next month. As the planet gains altitude it passes by the 1st magnitude star Regulus (Alpha Leonis). On the 6th, the pair will be 0.8° apart with Mercury being the northward and brighter of the two. On the 10th, the thin crescent 2-day old Moon will be 4.5° from the planet (see Sky View).

VENUS is at its greatest elongation (46°) east of the Sun on the 22nd, and spends the month high in the western evening sky in Virgo. The 4-day old crescent Moon will be 6.2° north of the planet

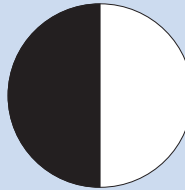
APPEARANCE of the PLANETS

MERCURY



VENUS

22th Aug
Gt Eastern
Elongation
dia 24.27"
mag -4.3

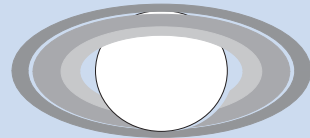


MARS

15th Aug
dia 3.51"
mag 1.7

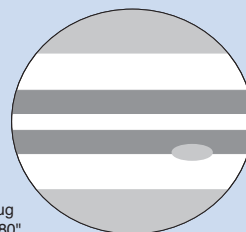


SATURN



15th Aug
dia 17.36"
mag 0.1

JUPITER



15th Aug
dia 31.80"
mag -1.8

URANUS

20th Aug
Opposition
dia 3.71"
mag 5.7



NEPTUNE

2nd Aug
Opposition
dia 2.34"
mag 7.8



PLUTO

15th Aug
dia 0.11"
mag 13.8



on the 12th (see Sky View). Venus increases altitude a little during the month, meeting up with the setting 1st magnitude star Spica (Alpha Virginis). The pair are closest on the 31st and 1st September at just under 1° apart (see Sky View next month). Also during August, Venus visits a number of galaxies in the Virgo cluster.

MARS, in conjunction with the Sun on the 11th, will remain lost in the Sun's glare until its return to the morning sky in October.

JUPITER returns to the morning eastern dawn sky after its solar conjunction last month. On the 31st, Jupiter will be 1.5° above the famous Beehive cluster or Praesepe (M44), an open cluster of about 200 stars visible to the unaided eye from dark skies (closest approach is next month).

SATURN, rising around 3am, begins the month 0.7° below M1, the Crab Nebula in Taurus. Closest approach occurred last month at 0.03° , which at the time was nearer to the planet than Saturn's satellite Titan. On the 5th, the 25-day old Moon will be 4.5° from the planet (see Sky View).

URANUS is at opposition on the 20th and is visible the entire night. On the 22nd, in the early evening the Full Moon will be 5° from the planet (closer as the night progresses). Uranus has been in Aquarius since the end of March, now its retrograde motion brings

the planet back across the border into Capricornus on the 10th. It will remain now in Capricornus until late January 2003.

NEPTUNE is at opposition on the 2nd, and on this day, if any Neptunians happen to be looking our way, they will witness a transit of the Earth and Moon across the face of the Sun. This rare series of transits began in 2001, and will continue at each opposition until the year 2006. On the 21st, in the early evening the Full Moon will be 4.5° from the planet (further as the night progresses).

PLUTO, now two months past opposition, transits the meridian around 7pm.

MINOR PLANETS at opposition this month include: 2 Pallas on the 4th at magnitude 9.4 in Delphinus, 7 Iris on the 24th at magnitude 7.8 in Aquarius and 532 Herculina on the 16th at magnitude 10.2 in Piscis Austrinus. A faint 28 Bellona visits the Virgo cluster of galaxies this month.

COMETS

Comet 7P/Pons-Winnecke moves through Phoenix during August, and is visible for most of the month. On 10th August, the comet is

through their cycle of fading, and then brightening again, with only binoculars or even the naked eye. These few stars are ideal for the beginner. Some stars only vary by a fraction of a magnitude but it is not unusual for others to change by at least 4 to 6 magnitudes. To visualise 6 magnitudes try looking at the brightest star, Sirius (mag. -1), and compare it to the faintest stars you can see (around mag. 5 to 6).

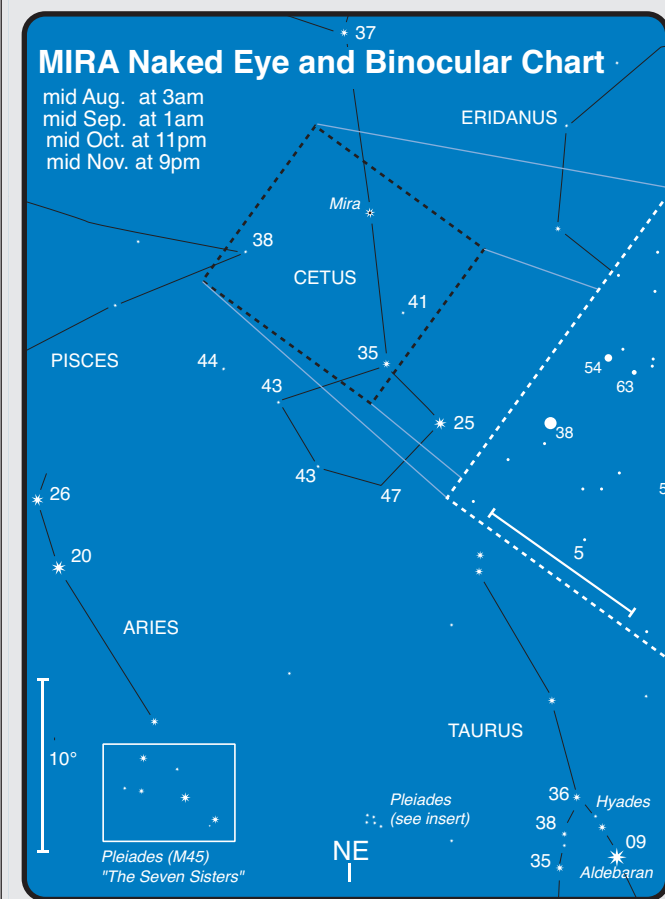
Variable stars are split into a number of classes. The most common variables are the long period pulsating types. Thousands of these 'Mira' variables have now been catalogued. Mira, itself, was discovered back in 1596 by Fabricius, but he thought it was a nova. Bayer even included it in his star catalogue in 1603 thinking it was a normal 4th magnitude star, calling it Omicron Ceti. However, its strange nature was soon discovered. Being the first variable discovered it was considered appropriate to name it Mira, 'The Wonderful'.

Mira is an excellent variable for beginners and this article is a guide to observing the star in 2002. At its brightest the star averages around 3rd magnitude (although historically it has peaked anywhere from 4th to 2nd) - definitely a naked eye star even from a suburban location. The star then fades to around 9th magnitude, now a binocular or small telescope object.

A full cycle from peak to peak is 330 days. Therefore the star reaches maximum about one month earlier than the previous year. The 2001 peak was in the first week of September. In 2002 it will reach maximum in early August. The star is in conjunction with the Sun in April/May and then moves into the morning sky. It is easiest for a beginner to pick it up at maximum and follow its decline. By mid August the star is rising before midnight, but it is best to wait 2-3 hours to allow it to gain altitude before attempting any magnitude estimates. Mira is in an area devoid of bright stars, so binoculars will help from light polluted skies. If you wait for Taurus to rise, the arrowhead of the Hyades will point you in the right direction. Based on 400 years of observations, the star is expected to fade to its minimum 200 days after maximum (it fades slower than it brightens). The minimum is therefore expected around March 2003. It will be possible to follow the star until February when it will start to get lost in the western evening twilight sky.

MIRA - A VARIABLE STAR FOR BEGINNERS

To the casual stargazer it may come as a surprise to learn that the brightness of all stars is not as constant as they seem. In fact, astronomers (many of them amateurs) have discovered tens of thousands of stars whose brightness varies over periods ranging from minutes to years. The amplitude (how much they change in brightness or their range of magnitudes) and how long it takes for one cycle (to be bright, fade and brighten again) varies greatly from star to star. Most of these objects are faint and require a telescope to observe them. However, there are a number of these stars that are quite bright. Brilliant enough for people to observe them go



AUGUST

just over two degrees from 2nd magnitude Alpha Phoenicis. By month's end, the comet has faded from 12th to 13th magnitude.

Comet 22P/Kopff can be found in Virgo in the evening sky, visible for a few hours after the end of twilight. It should brighten from 13th to 12th magnitude. In early August, the comet is less than two degrees from 3rd magnitude Gamma Virginis.

Comet 46P/Wirtanen reaches its peak brightness of 10th magnitude this month. Wirtanen also reaches perihelion this month on 26th August at 1.1 AU from the Sun, and mid-month it is at its closest to Earth during this apparition - a distant 1.6 AU. The comet is very low in the morning sky before dawn, moving through the constellations of Taurus, Orion, Gemini, and Cancer. On the 9th and 10th of August, Wirtanen is very close to the 4th magnitude star Nu Geminorum.

Comet 67P/Churyumov-Gerasimenko reaches perihelion this month on 18th August at 1.3 AU from the Sun. The comet should stay around 13th magnitude. On the morning of 5th August, the comet will be very near Saturn and the supernova remnant M1, with a crescent Moon nearby. A week later, the comet has crossed over into the constellation of Gemini and is less than a degree from the open cluster M35. Capping off an interesting month of conjunctions, Churyumov-Gerasimenko is about a degree from 3rd magnitude Epsilon Geminorum on 21st August and less than half a degree from 5th magnitude Omega Geminorum on 26th August.

Comet P/1992 Q1 (Brewington) should brighten from 12th to 11th magnitude this month. The comet is visible all night and moves from Microscopium into Sagittarius. In late August, Brewington is at its closest to Earth during this apparition (1.56 AU), even though perihelion isn't until February 2003.

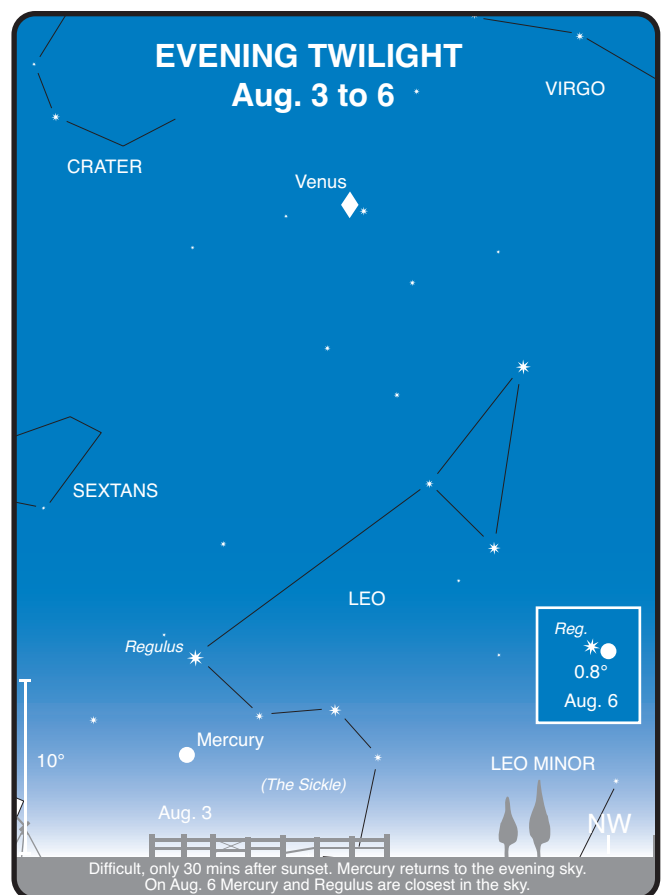
METEOR SHOWERS

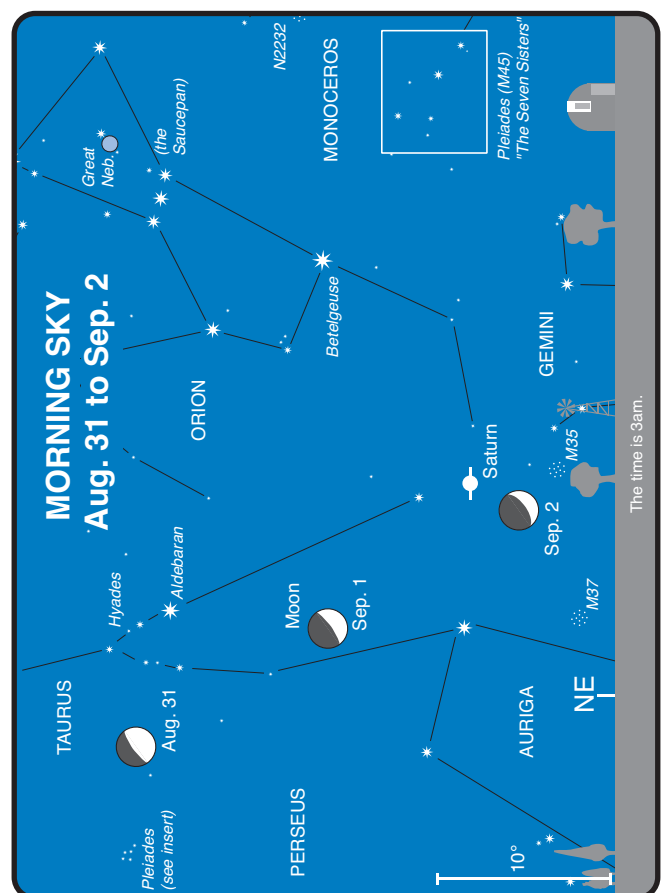
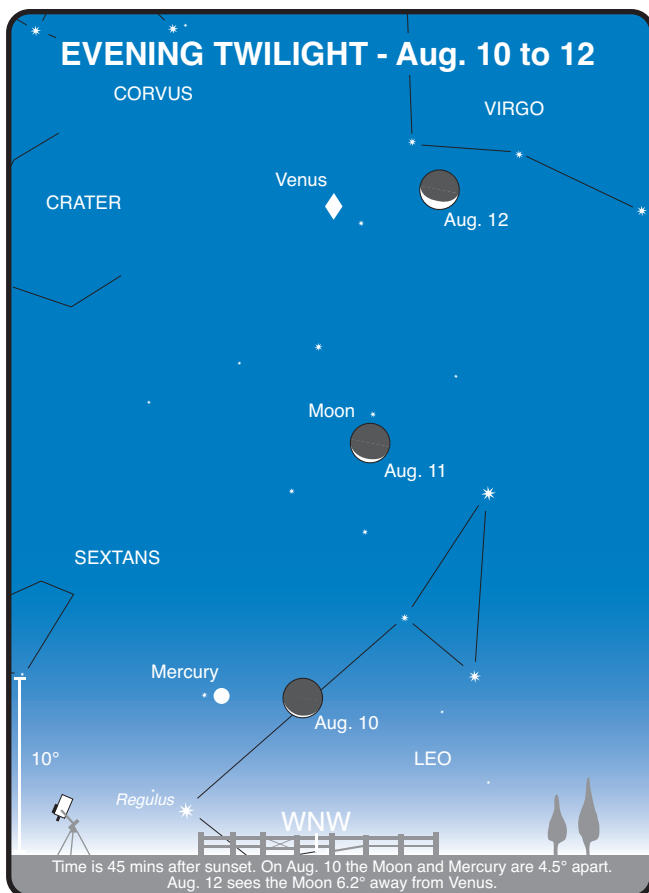
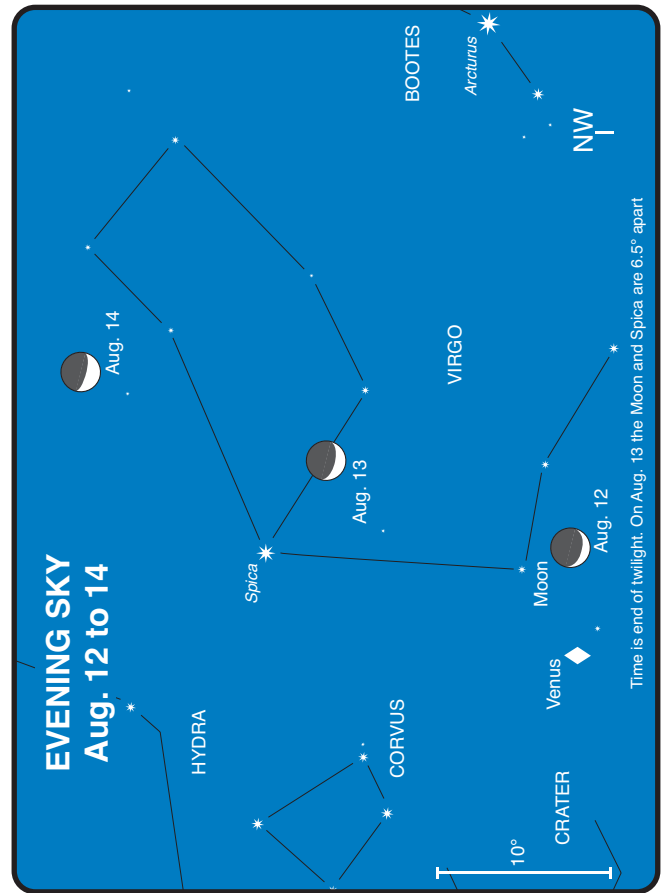
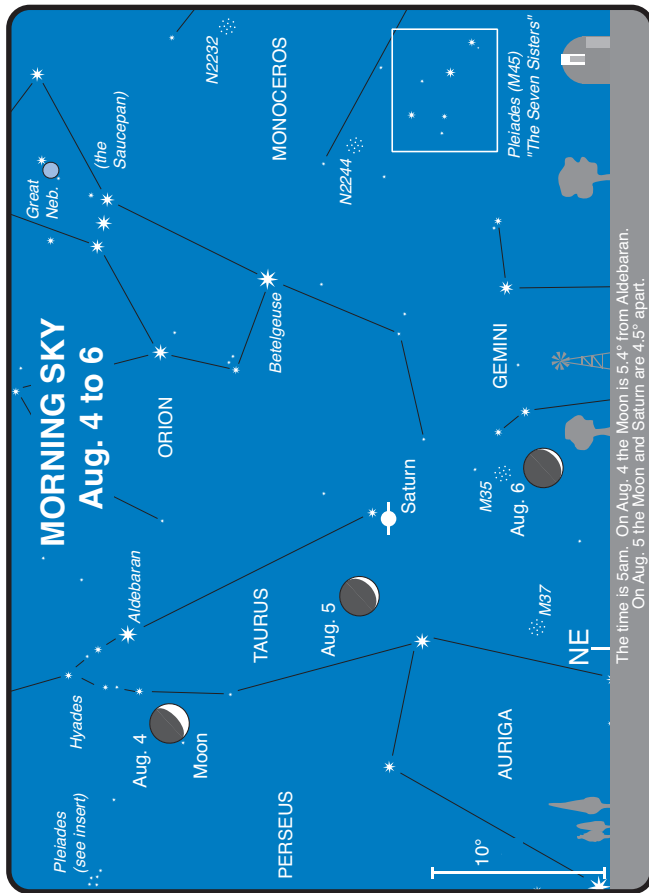
The **Perseids** unfortunately are not easily observable for most southern observers, and for southern Australia the radiant will be below the horizon. The Perseids are probably the most dependable of the showers, with records of their activity going back over one thousand years. The duration is from 17th July through to 24th August, with maximum on the 12th August. The zenith hourly rate is variable and has in the past being exceptional; 1991 and 1992 saw over 400, in 1993 around 300 and 1994 was 220. Since then respectable rates of between 120-160 have occurred. There could still be some surprises in the shower activity, but the rates have gradually declined since 1992 when the Perseids parent comet Swift-Tuttle reached perihelion.

DIARY

1st	8:22 PM	Last Quarter Moon
2nd	11 AM	Neptune at opposition
3rd		Venus at descending node
3rd	8 PM	Comet 22P/Kopff 0.03°N of NGC 4666 (SG) in Virgo
5th	2 PM	Saturn 2°S of Moon
6th		Comet 46P/Wirtanen 0.5°S of NGC 2175 (OC) in Orion
6th	2 PM	Mercury 0.9°N of Regulus
7th	8 PM	Comet 22P/Kopff 0.2°W of NGC 4753 (IG) in Virgo
8th		Venus 0.7°NE of NGC 4030 (SG) in Virgo
9th	5:15 AM	New Moon
10th		m.p. 27 Euterpe 0.5°SW of NGC 4691 (SG) in Virgo
10th	11 AM	Mercury 4°S of Moon
11th	8 AM	Mars in conjunction with Sun
11th	9 AM	Moon at perigee
12th	8 AM	Venus 6°S of Moon
12th	10 PM	Pallas at opposition
14th		Mars at greatest latitude North
14th		m.p. 28 Bellona 0.2°S of M61 (SG) in Virgo
15th		m.p. 654 Zelinda 0.2°SE of NGC 3962 (EG) in Crater

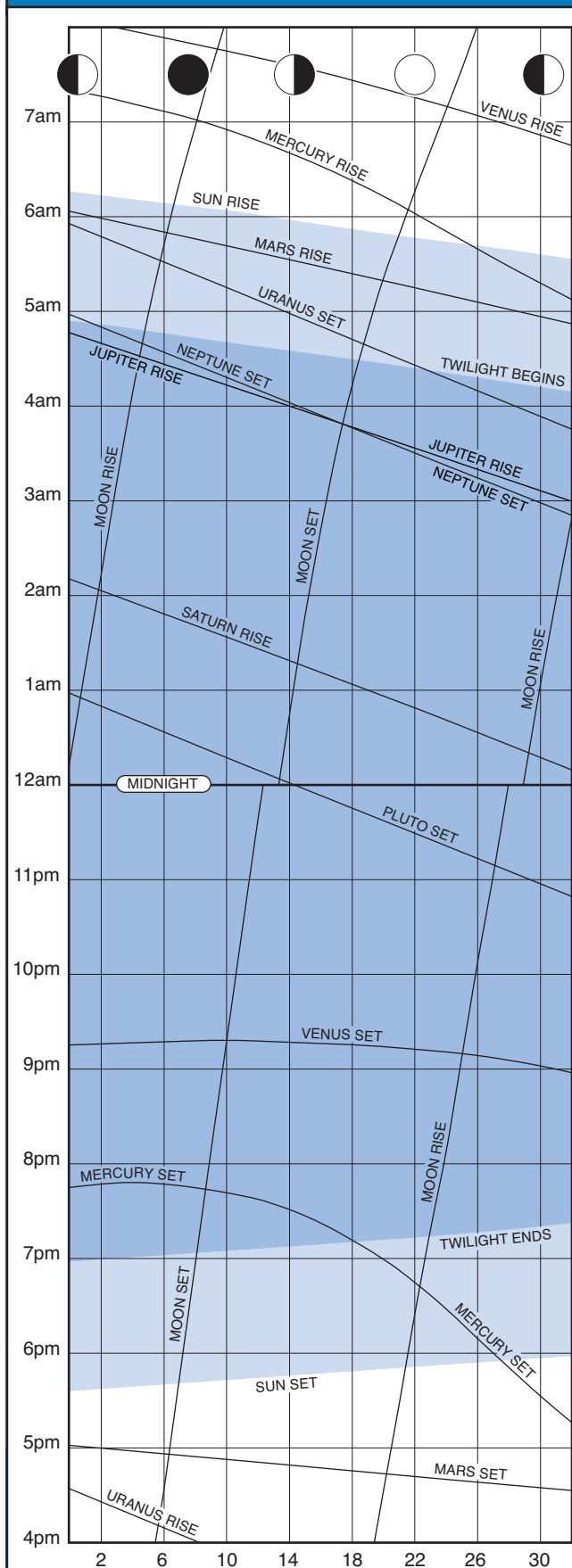
15th	8:12 PM	First Quarter Moon
17th		Mercury at descending node
18th	1 AM	Ceres stationary
18th		Venus 0.4°SW of NGC 4593 (SG) in Virgo
19th		m.p. 28 Bellona 0.2°SE of NGC 4457 (EG) in Virgo
19th		Mercury 0.7°NE of NGC 3640 (EG) in Leo
20th		Venus 1°SW of NGC 4697 (EG) in Virgo
20th	11 AM	Uranus at opposition
21st		Venus 0.8°SW of NGC 4731 (SG) in Virgo
21st	2 PM	Neptune 4°N of Moon
22nd		m.p. 27 Euterpe 0.1°S of NGC 4941 (SG) in Virgo
22nd		m.p. 28 Bellona 0.3°N of NGC 4527 (SG) in Virgo
22nd	11 PM	Venus greatest elongation E (46°)
22nd	Midnight	Uranus 4°N of Moon
23rd	5 AM	Comet 46P/Wirtanen 0.2°SW of Eskimo Nebula (PN) in Gemini
23rd	8:29 AM	Full Moon
23rd		Venus 0.5°N of NGC 4818 (SG) in Virgo
25th		Comet 46P/Wirtanen 0.9°S of NGC 2420 (OC) in Gemini
26th		m.p. 28 Bellona 0.7°SW of NGC 4636 (EG) in Virgo
26th		m.p. 8 Flora 1°SW of NGC 4536 (SG) in Virgo
26th		Venus 1°NE of NGC 4939 (SG) in Virgo
27th	4 AM	Moon at apogee
27th		Mercury at aphelion
27th		Mercury 0.6°S of NGC 4030 (SG) in Virgo
28th	6 AM	Pluto stationary
28th	7 PM	m.p. 28 Bellona 0.05°S of NGC 4643 (SG) in Virgo
29th	9 PM	m.p. 7 Iris 0.4°S of star Alpha Aquarii
31st		m.p. 654 Zelinda 0.4°S of star Delta Corvi
31st	12:31 PM	Last Quarter Moon





SEPTEMBER

RISE/SET CHART



All times are AEST.

SEPTEMBER HIGHLIGHTS

- Mercury at its best for evening observation
- Venus and Spica close
- Venus at greatest brilliancy
- Jupiter passes by M44's outer regions

THE MOON

- 7th New Moon
- 8th Moon at perigee (closest to Earth – 358,746 km distant, angular size 33.8')
- 14th First Quarter
- 21st Full Moon
- 23rd Moon at apogee (furthest from Earth – 406,352 km distant, angular size 29.0')
- 30th Last Quarter

THE PLANETS

MERCURY reaches its greatest elongation east of the Sun on the 1st at 27°, setting 2 hours after the Sun. The last two weeks of August, and the first two weeks of this month, provide the planet's best viewing window in the evening sky this year. In Virgo for the entire month, this rapidly moving planet's evening apparition is short lived. Descending back into the evening twilight, Mercury is in inferior conjunction on the 28th (between Earth and Sun), and returns to the morning twilight next month.

APPEARANCE of the PLANETS

MERCURY

1st Sep
Gt Eastern
Elongation
dia 7.12"
mag 0.2

Mercury is in inferior conjunction on the 28th

15th Sep
dia 9.14"
mag 1.0

25th Sep
dia 10.36"
mag 2.4

VENUS

15th Sep
dia 33.28"
mag -4.5

MARS

15th Sep
dia 3.55"
mag 1.8

SATURN

15th Sep
dia 18.27"
mag 0.1

URANUS

15th Sep
dia 3.69"
mag 5.7

NEPTUNE

15th Sep
dia 2.33"
mag 7.9

PLUTO

15th Sep
dia 0.11"
mag 13.9

JUPITER

15th Sep
dia 33.08"
mag -1.9

VENUS, in the western evening sky, begins the month just 1° from the 1st magnitude star Spica (Alpha Virginis). The separation from Spica increases throughout the month and during the last week the planet moves from Virgo into Libra. On the 10th, the 4-day-old crescent Moon appears 7.4° north of the planet (see Sky View). Venus attains its greatest brilliancy (magnitude -4.6) in the evening sky at month-end, outshining the brightest star Sirius (Alpha Canis Majoris) by a factor of 12. Interestingly, the planet is so bright that it can cast a perceptible shadow, visible only under good dark skies away from city lights. Venus' prominence as the Evening Star over the past six months is ending, with the planet in conjunction with the Sun late next month.

The **EARTH** is at its vernal (spring) equinox on the 23rd. The Sun rises and sets due east and west and day and night are equal.

MARS returns to the morning sky after its solar conjunction last month, albeit remaining close to the Sun and making observations difficult until late October.

JUPITER, rising about 30 minutes (mid-month) before the commencement of dawn, starts the month in Cancer just 1.5° from the famous Beehive cluster or Praesepe (M44). The planet passes by the cluster's outer fringes on the 6th. The thin crescent Moon will be 5.7° below the planet on the 5th (see Sky View).

TRANSIENT LUNAR PHENOMENA

For a lot of amateur astronomers the Moon is something they may only occasionally look at, or be the trump card to be wheeled out at public field nights to ensure a high wow factor! Very few would look at our celestial neighbour as a target for a serious, long term observing project. One such area is looking for Transient Lunar Phenomena (TLPs). For hundreds of years observers have reported strange, short-term changes on the Moon. These reports have even come from Apollo astronauts and the great observer Herschel who once described Aristarchus - "like a nebula - like glowing coals". These events fit into four broad categories: brightness variation, obscurations (such as fogs or mists), star-like flashes and colour abnormalities. They are by no means randomly distributed across the surface but tend to re-occur in specific lunar features. This is just as well for it would be impossible to learn the entire visible surface of the Moon to the level needed to make meaningful observations.

What do TLPs look like?

Brightening. This effect is mostly seen on crater rims or highland areas. Seen in Aristarchus, Proclus and Censorinus.

Gaseous. This is when an object looks diffused and can appear obscured. This may be associated with an outgassing from the Moon's interior. This has been seen by many observers in the Mare Crisium basin. Also small craters on the interior of Plato have been 'missing' for short periods.

Darkening. This can have the dramatic appearance of black ink flowing across the lunar surface. Aristarchus, Linnie and Plato have been known to show this feature.

Colour effects. A 'bluish' glow has been seen during the crescent phase but on the darkened, or earthshine, portion of the Moon. Aristarchus is the most common site. The rim of Aristarchus and the inside of the crater Gassendi have been the sites for a strange red colour.

Shadow and Contrast Effect. This can be the appearance of a shadow on the surface where one shouldn't be. Also the normal stark boundary between light and dark at sunset or sunrise can appear to be 'greyed'.

Star-like Flashes. Unlike most TLPs the cause of these are likely to be impacting particles related to a meteor storm. A recent example was the reporting of flashes during the Leonids peak in 1999.

Star-like Lights. A stellar point of light is observed and can last for several minutes up to an hour. These are mostly seen on the dark portion of the Moon when the Moon is 3 to 4 days old.

What causes TLPs?

There are many and varied theories of which there is little space to go into here. A commonly believed contributor is the tidal pull of the Earth, which does strain the lunar crust and may release trapped gases. See also the discussion on the ALPO web site (below).

How and where does one look for TLPs?

A good approach would be to pick 5 or 6 regions, including 3 known TLP sites, and observe them under all possible levels of illumination. This would include, the terminator crossing the feature from both directions i.e., local sunrise and sunset, at Full Moon and only earthshine (no direct sunlight). The size of the telescope is not critical, although it is recommended that reflectors to be at least 20cm. There is no doubt that observers using larger scopes (such as 30cm) report more such phenomena. A high contrast is also considered desirable so a refractor may offer some advantages. It is important, when one detects a TLP, to look at a number of other features across the lunar disk. If they all show the same event you may be seeing an effect from local atmospheric seeing and not a lunar feature at all.

With regards to which features to observe, Aristarchus, as well as being the brightest feature on the Moon, has been by far, the most prolific TLP site. Plato would be the next most active area, followed by Proclus.

The British Astronomical Association (BAA) and the Association of Lunar and Planetary Observers (ALPO) have active TLP sections. They would be pleased to receive any such observations and have available guides to observing and reporting such events. The following web site, which includes TLP alerts, would be a good start (www.ltpresearch.org/nav.htm).



Aristarchus (arrowed) is the brightest region on the Moon and the most common location for TLPs (south is up).

SEPTEMBER

SATURN, rising around 1am mid-month, moves into Orion in September after spending more than 2 years in Taurus. It will be a brief sojourn however, as the planets retrograde motion returns it to Taurus in November. The Moon has close approaches to the planet twice this month, on the 2nd the 24-day old Moon will be 3.7° below Saturn (see Sky View) and on the 29th, 6.2° away (see Sky View).

URANUS and **NEPTUNE** in Capricornus are now one month past opposition and are visible for virtually the entire night.

PLUTO is only available to keen observers (with large enough telescopes and our finder chart on page 119), in the evening sky, setting around midnight.

MINOR PLANETS at opposition this month include 15 Eunomia on the 7th at magnitude 8.1 in Pegasus.

COMETS

Comet 22P/Kopff is low in the western evening sky after the end of astronomical twilight. Kopff should brighten from 12th to 11th magnitude during the month as it moves from Virgo into Libra. In mid-September, the comet is about a degree from 4th magnitude Kappa Virginis.

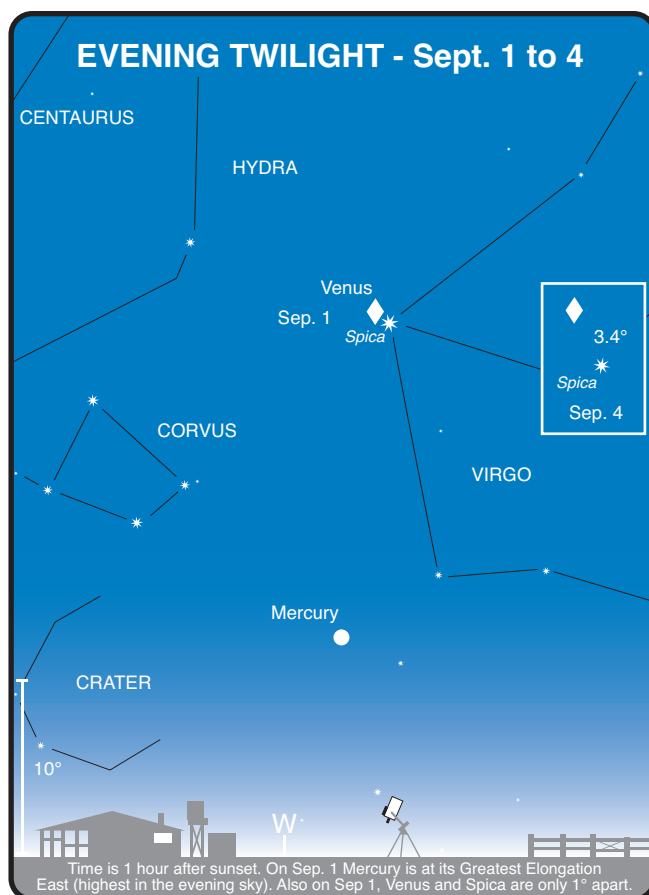
Comet 46P/Wirtanen will be difficult to observe this month, rising around the time of morning twilight. The comet should fade from 10th to 11th magnitude as it moves away from both the Earth and the Sun. Wirtanen moves from Cancer into Leo during this time, ending the month about a degree from 4th magnitude Eta Leonis. The 8th September sees the comet pass in front of the open cluster M44, with Jupiter 1° away.

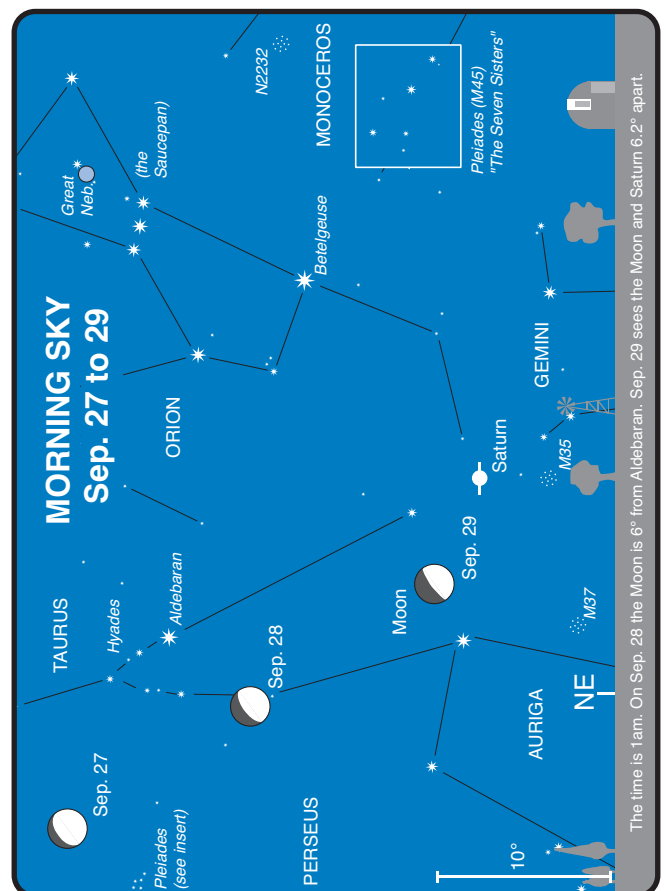
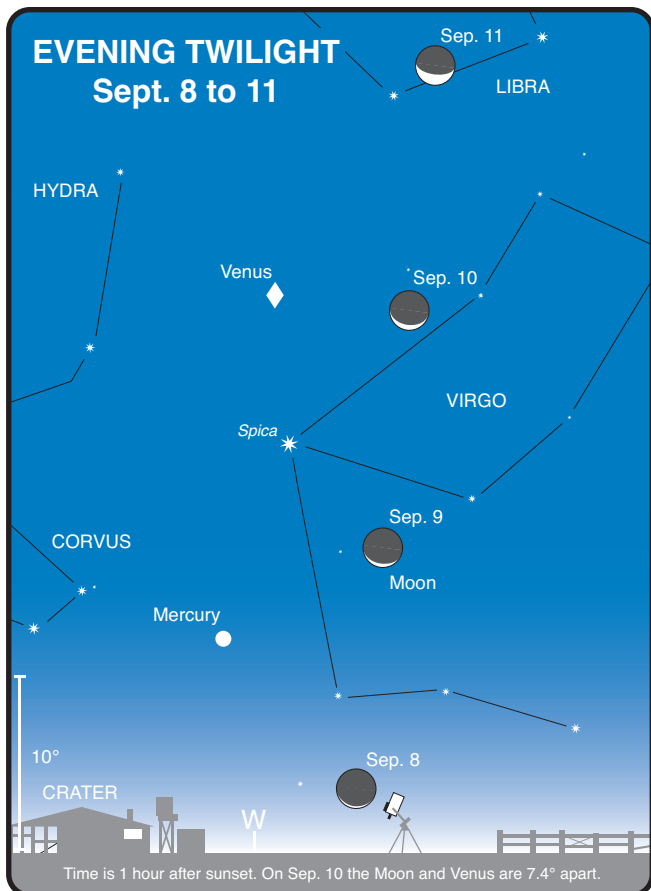
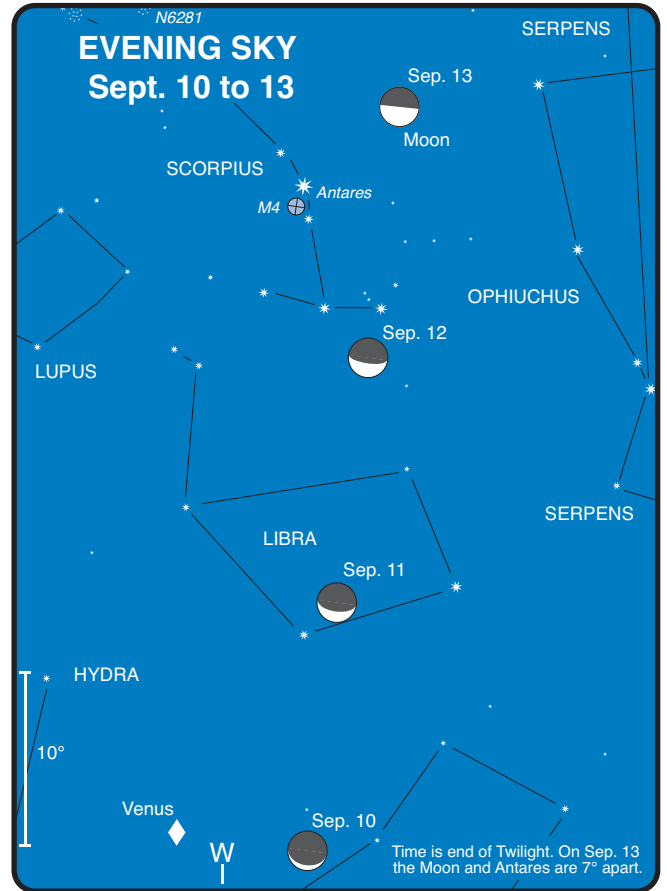
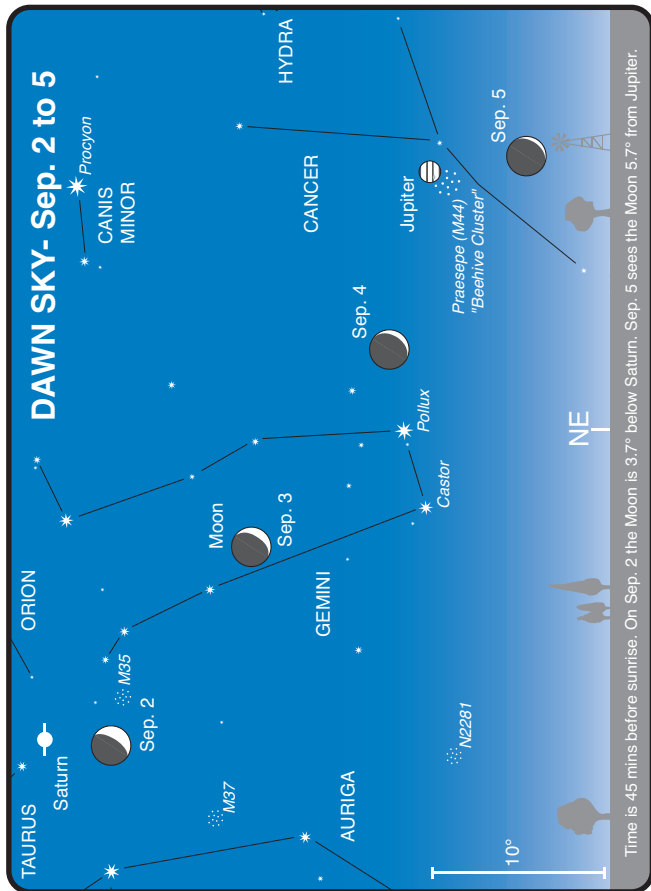
Comet P/1992 Q1 (Brewington) is high in the eastern sky when evening twilight concludes this month. The 11th magnitude comet can be found in Sagittarius and sets a few hours before dawn. On 3rd September, the comet is less than a degree from 4th magnitude Theta 1 Sagittarii. Three days later, the comet glides past 5th magnitude Theta 2 Sagittarii. In late September, Brewington is less than 4° from the globular cluster M55.

DIARY

1st	4 PM	Venus 0.9°S of Spica
1st	8 PM	Mercury greatest elongation E (27°)
2nd	3 AM	Saturn 2°S of Moon
4th		m.p. 8 Flora 0.4°NE of NGC 4666 (SG) in Virgo
4th	11 PM	Jupiter 4°S of Moon
6th		Jupiter 1°S of Beehive Cluster M44 (OC) in Cancer
7th		Venus at aphelion
7th		Mercury 0.7°NE of NGC 4504 (SG) in Virgo
7th	1:10 PM	New Moon
7th	11 PM	m.p. 15 Eunomia 0.7°N of NGC 7479 (SG) in Pegasus
8th		Comet 46P/Wirtanen 0.2°S of Beehive Cluster M44 (OC) in Cancer
8th		Comet 46P/Wirtanen 1°N of Jupiter
8th		m.p. 8 Flora 0.3°N of NGC 4753 (IG) in Virgo
8th		Saturn 0.4°N of Berk 21 (OC) in Orion
8th	1 PM	Moon at perigee
9th	3 AM	Mercury 9°S of Moon
10th	Noon	Venus 8°S of Moon
11th	9 PM	m.p. 2 Pallas 0.3°W of NGC 6934 (GC) in Delphinus
14th	4:08 AM	First Quarter Moon
14th	Midnight	Mercury stationary

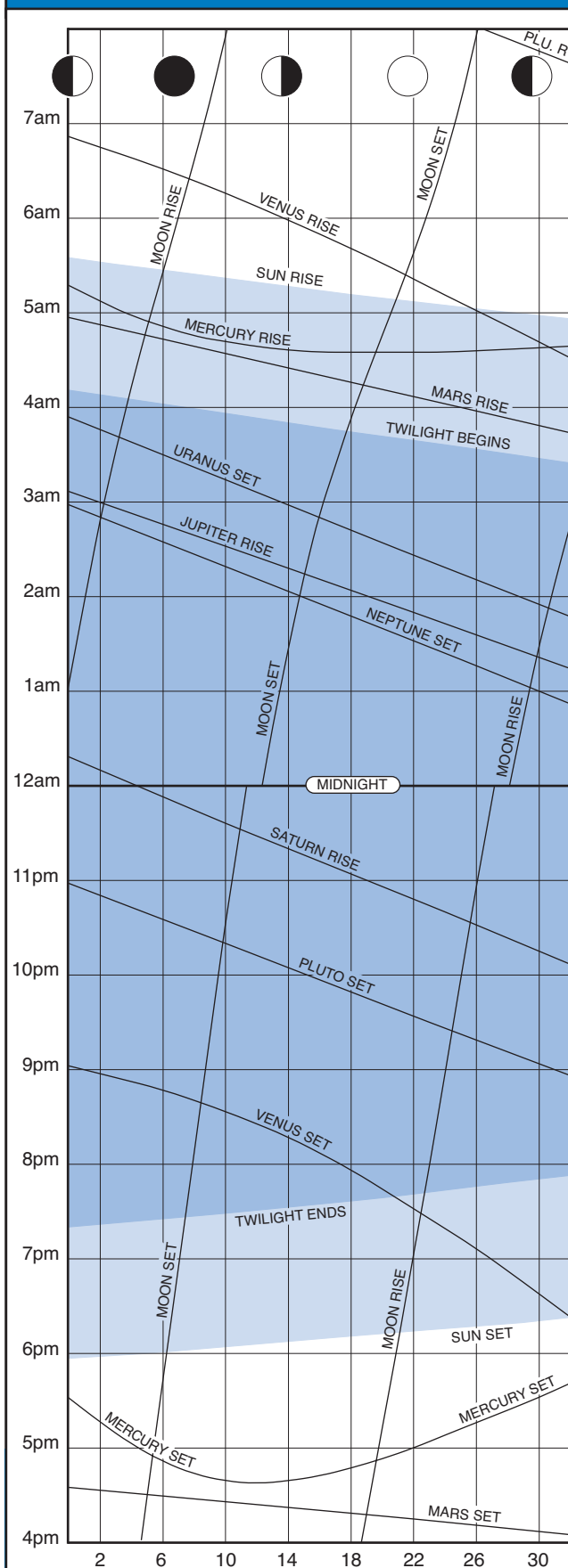
15th	9 PM	m.p. 6 Hebe 0.6°SW of M18 (OC) in Sagittarius
16th		Mercury at greatest latitude South
17th	7 PM	Neptune 4°N of Moon
19th	4 AM	Uranus 4°N of Moon
19th		m.p. 654 Zelinda 0.6°SW of NGC 5018 (SG) in Virgo
21st		Mars at aphelion
21st		Mercury 0.4°SE of NGC 4504 (SG) in Virgo
21st	11:59 PM	Full Moon
23rd		m.p. 654 Zelinda 0.5°NE of NGC 5068 (SG) in Virgo
23rd	1 PM	Moon at apogee
23rd	3 PM	Equinox
25th		m.p. 25 Phocaea 0.1°SE of IC 4756 (OC) in Serpens
26th	9 PM	Venus greatest brilliancy
28th	5 AM	Mercury in inferior conjunction
29th		Venus at greatest latitude South
29th	1 PM	Saturn 3°S of Moon
29th	11 PM	m.p. 6 Hebe 0.3°N of M25 (OC) in Sagittarius
30th	3:03 AM	Last Quarter Moon
30th	10 AM	Pallas stationary





OCTOBER

RISE/SET CHART



All times are AEST. For daylight saving add 1 hour.

OCTOBER HIGHLIGHTS

- Mercury greatest elongation in morning twilight
- Last chance to view Venus in the evening sky

THE MOON

- 6th New Moon
- 6th Moon at perigee (closest to Earth – 356,918 km distant, angular size 33.0')
- 13th First Quarter
- 20th Moon at apogee (furthest from Earth – 406,360 km distant, angular size 29.2')
- 21st Full Moon
- 29th Last Quarter

THE PLANETS

MERCURY in Virgo moves into the dawn sky this month, reaching its greatest elongation from the Sun (18°) on the 13th. This morning apparition is a poor one with the Sun rising soon after the planet.

VENUS loses its stature as the Evening Star this month as it moves into inferior conjunction (between the Earth and the Sun) on the 31st, returning to the morning twilight in November. For the first two weeks of October however, the planet is still brilliant in the evening sky, gradually losing altitude each evening as it moves toward the Sun.

APPEARANCE of the PLANETS

MERCURY



5th Oct
dia 8.95"
mag 1.2



13th Oct
Gt Western
Elongation
dia 7.00"
mag -0.5



25th Oct
dia 5.38"
mag -1.0

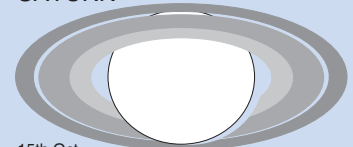


VENUS

15th Oct
dia 53.46"
mag -4.5

Venus is in
inferior conjunction
on the 31st

SATURN

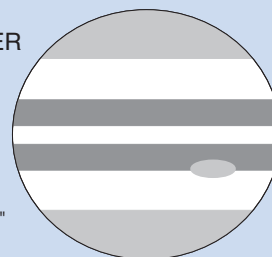


15th Oct
dia 19.30"
mag -0.1

MARS

15th Oct
dia 3.68"
mag 1.8

JUPITER



15th Oct
dia 35.32"
mag -2.0

URANUS

15th Oct
dia 3.63"
mag 5.8

NEPTUNE

15th Oct
dia 2.29"
mag 7.9

PLUTO

15th Oct
dia 0.11"
mag 13.9

MARS rises an hour before the Sun in the morning twilight. The Red Planet resides in Leo for the first week of October before moving into Virgo.

JUPITER rises in the NE sky around 2am in the constellation of Cancer. On the 30th, the Last Quarter Moon will be 6.2° from the planet.

SATURN rises around 11pm and is located in a corner of Orion near the tip of the hunter's sword. On the 26th, the 20-day old Moon will be 5° below Saturn (see Sky View).

URANUS and **NEPTUNE**, in Capricornus, transit the meridian in the early evening.

A CHEAP EQUATORIAL CAMERA PLATFORM

Glenn Dawes

In the astrophotography article on page 49, it was mentioned that even with a 50mm lens, if the exposure goes beyond about 30 seconds, you need to track the stars to avoid 'trailing' of the image. Unfortunately a 30-second exposure doesn't get one anywhere near the potential described in this previous article. It is certainly convenient to hang the camera off a telescope and let it guide. Figure 1 is the telescope with the camera I used to do all my patrol photography. This is ideal but we don't always have the thousands of dollars to invest in such equipment.



Fig 1

This article offers a possible, much cheaper alternative (figure 2). I originally dreamed up the idea for portability when travelling overseas. Besides your camera and cable lock all that is needed is a sturdy tripod, a camera slow motion control (available from telescope suppliers for around \$100), a right angle mount, a small spirit level and a compass (the straight edged type, used on maps would be ideal). The 'right angle mount' was the only engineering

involved. I used a section of 50mm, square rolled hollow section (RHS) steel. However, any channel will do as long as the camera is mounted at 90 degrees to the top of the slow motion control and the camera is able to swing freely.

An Equatorial Head. Set up the tripod, keeping the head low and the legs wide to improve stability. Level the tripod with the spirit level at point C (fig. 3). Then point the camera platform south by using a compass or the map compass placed on the edge D. You can even offset for the difference between the magnetic and true poles with a compass, however this isn't that critical for 5 minute shots. Tilt the tripod head back to line up the axis A, with the South Pole. This can be helped the first time by placing the straight edge of a vertically held protractor, along edge D and hanging a string with a weight and setting this to your latitude (e.g., 38° if you live in Melbourne). Mark the position at point E to avoid this step in the future. Then tilt the tripod forward elevating the head to the same angle but now pointing in the opposite direction (mark another point F). Tilt it back to E again. Mount the slow motion control where the camera normally goes. The goal then is to ensure the A and B axes are parallel. In this set up I found that lining up the front edge of the slow motion control to that of the camera platform (edge J) was sufficient (move the second axis, which is not used, to the centre position). We now have our makeshift equatorial mount. By unlocking the knob G we can swing the mount in right ascension (R.A.) Movement in declination is achieved by moving the camera itself on the right angle mount.

Calibrating the 'Tracking'. Finally we need to determine the speed in which knob H is turned to follow the stars. This can be done by centring the camera on a bright star and leaving it for an hour and seeing how many turns is needed to catch up to the

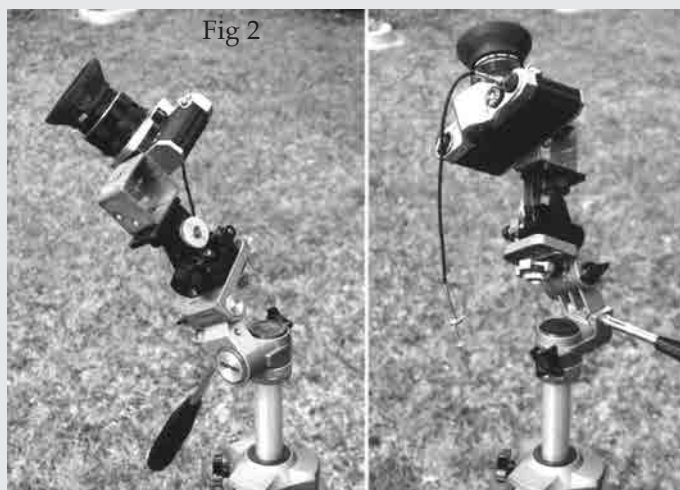


Fig 2

star (note which direction you had to turn the knob). Work out how many minutes per turn is needed. In practice while guiding, continuous turning of the knob isn't needed, as long as it is 'tweaked' the correct amount every 20 seconds or so. You will settle into your own style, maybe even setting up some audible signal every 20 seconds? The slow motion control, in this example needed only one full turn per 8 minutes. To help with the fine movement needed I have successfully experimented with putting a mark on the edge of the knob and placing a scale behind it.

Photographing the Whole Sky. The way it is shown in figure 3, i.e., south to the right, the tripod platform can only tilt towards the reader so you can only work on the western half of the sky (assuming Southern Hemisphere).

To get to the eastern half you tilt the tripod head to point F and swing the entire tripod head around 180° . Fig. 2 shows the tripod in both configurations. You will need to go through the exercise again of pointing to the south. Now you can resume your photography immediately. Note the direction that you have been turning knob H now needs to be reversed.

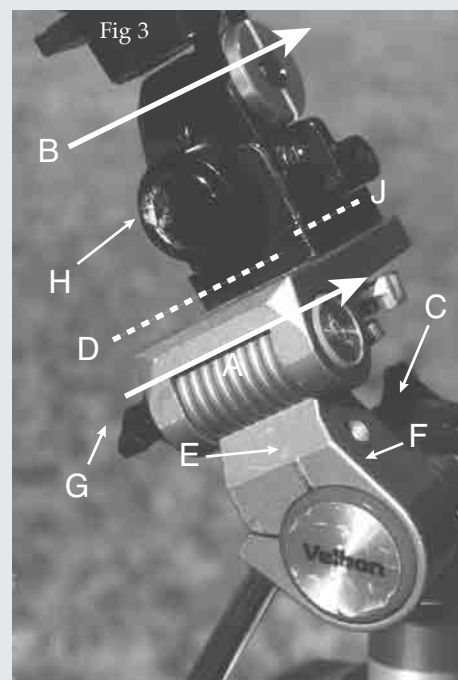


Fig 3

OCTOBER

PLUTO, moving toward conjunction in early December, sets in the evening around 10pm.

MINOR PLANETS at opposition this month include 1 Ceres on the 9th at magnitude 7.6 in Cetus and 18 Melpomene on the 2nd at magnitude 7.8 in Cetus.

COMETS

Comet 22P/Kopff continues to slowly brighten this month, from 11th to nearly 10th magnitude, but it is sinking closer to the western evening horizon with each night. In late October, the comet is only a few degrees from 4th magnitude Theta Librae. Kopff doesn't reach perihelion until 12th December, but after this month it will be too close to the Sun for observation again until late autumn 2003.

Comet 46P/Wirtanen fades from 11th to 13th magnitude this month. Although the comet does gain some altitude as its declination moves south, whilst traversing the constellations of Leo and Virgo, it will be a difficult object to observe. Early in the month, Wirtanen crosses the Leo group of galaxies.

Comet C/2001 HT50 (LINEAR-NEAT) can be found low in the eastern morning sky, brightening from 14th to 13th magnitude. LINEAR-NEAT spends the entire month in Sextans, moving quite slowly.

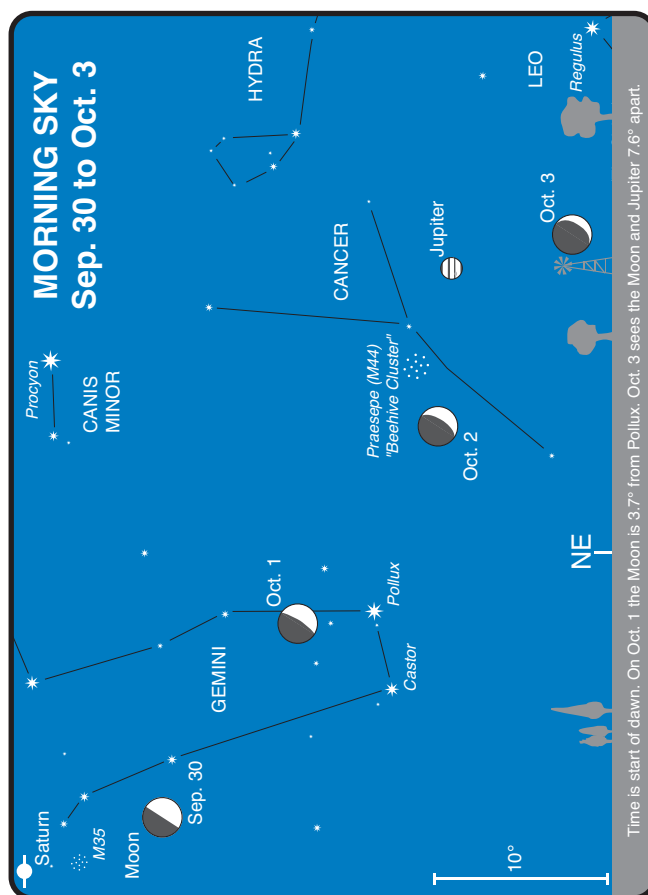
Comet P/1992 Q1 (Brewington) remains at 11th magnitude during October, and is high in the western evening sky following the end of astronomical twilight. During this month, the comet moves through the constellations of Sagittarius and Capricornus, and is setting shortly after midnight.

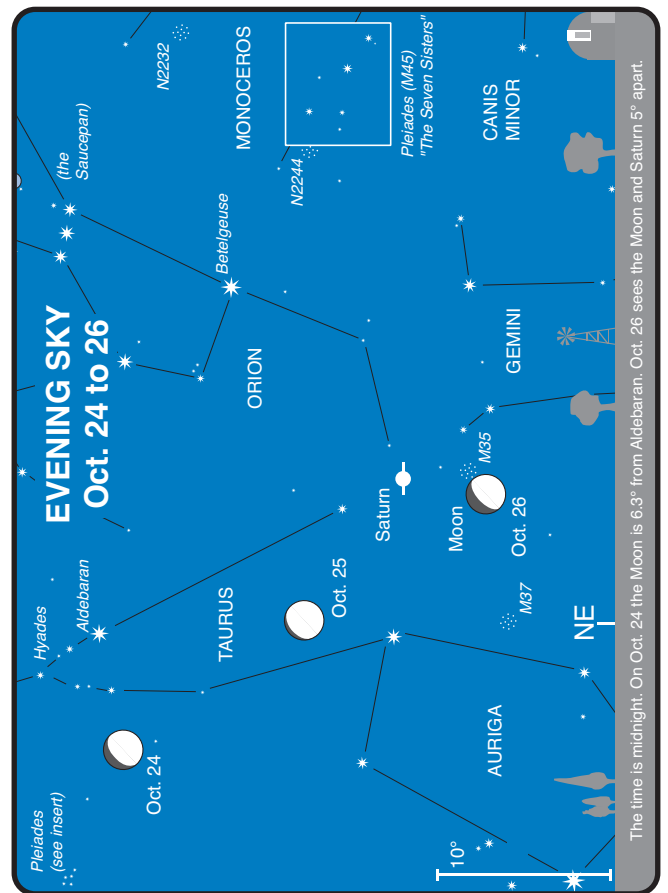
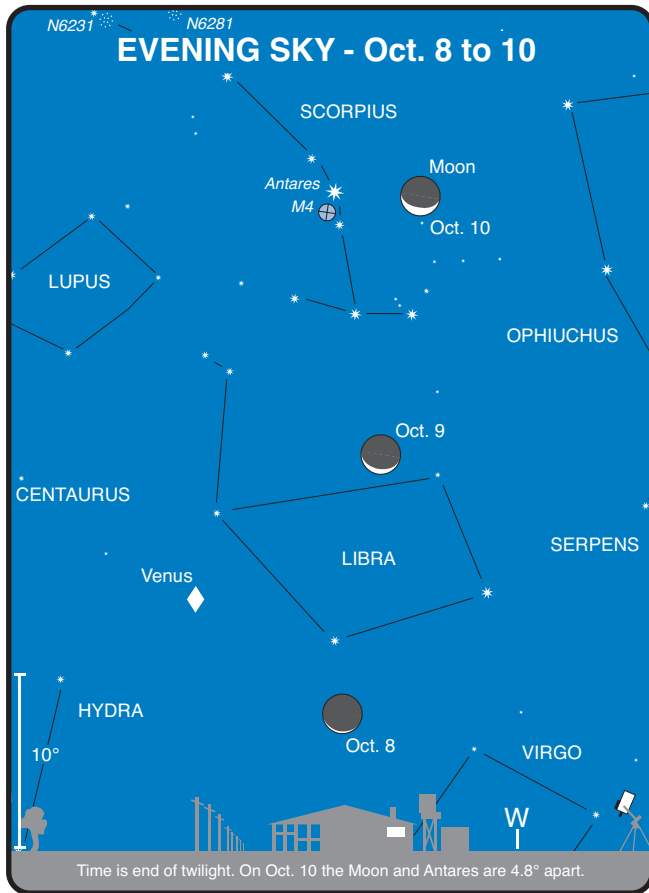
DIARY

2nd		Venus 0.2°NE of IC 4468 (SG) in Libra
2nd	5 PM	Jupiter 4°S of Moon
4th	8 AM	Juno in conjunction with Sun
4th	6 PM	Ceres at opposition
5th		Mercury at ascending node
5th	11 AM	Mars 4°S of Moon
6th	Noon	Mercury stationary
6th	9:18 PM	New Moon
6th	11 PM	Moon at perigee
8th		Jupiter 0.5°N of NGC 2734 (SG) in Cancer
8th	8 PM	Venus 10°S of Moon
10th		Mercury at perihelion
10th		Comet 46P/Wirtanen 0.2°N of NGC 3338 (SG) in Leo
10th	7 PM	Venus stationary
11th	11 PM	Saturn stationary
12th		Comet 46P/Wirtanen 0.4°SE of NGC 3377 (EG) in Leo
13th		Comet 46P/Wirtanen 0.2°E of NGC 3412 (EG) in Leo
13th		Mars 1°N of NGC 4546 (EG) in Virgo
13th	3:33 PM	First Quarter Moon
13th	6 PM	Mercury greatest elongation W (18°)
14th	Midnight	Neptune 5°N of Moon
16th	8 AM	Uranus 4°N of Moon
16th		m.p. 4 Vesta 0.1°N of M95 (SG) in Leo
18th		m.p. 4 Vesta 0.3°S of M96 (SG) in Leo
19th		Venus 0.5°SW of IC 4468 (SG) in Libra
20th		Mercury at greatest latitude North
20th		Comet 46P/Wirtanen 1°S of NGC 3593 (SG) in Leo

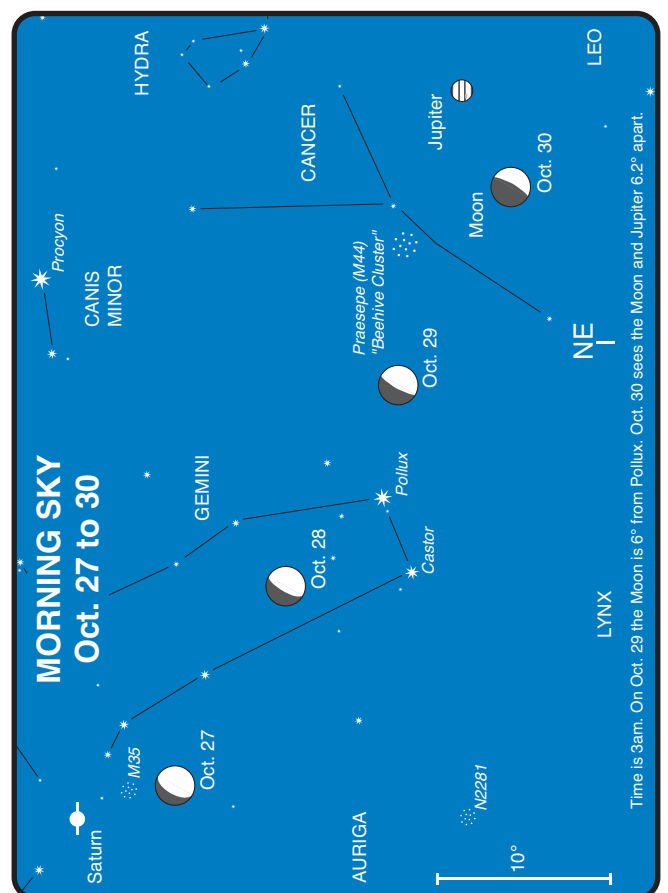
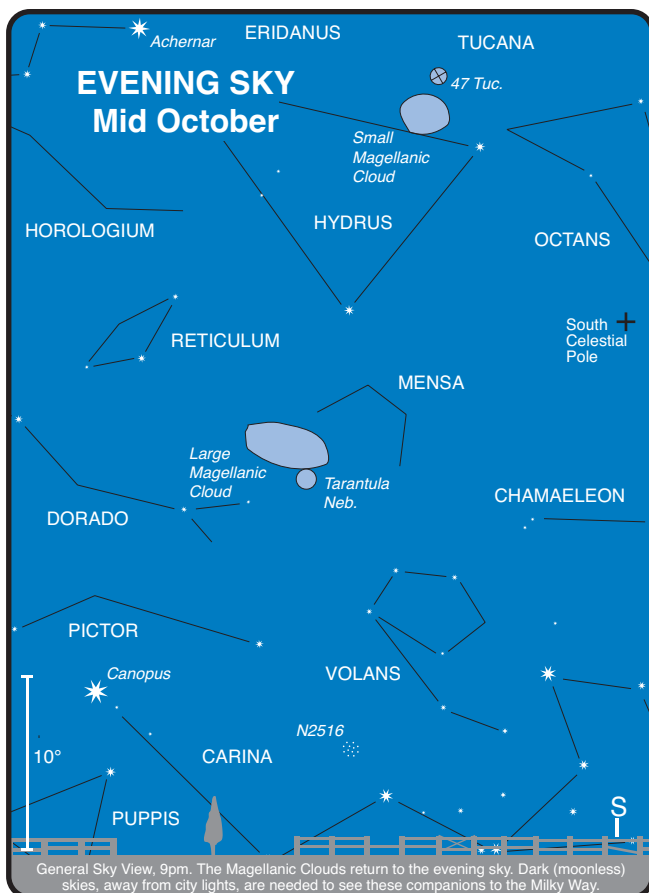
20th	3 PM	Moon at apogee
20th	9 PM	Neptune stationary
21st	5:20 PM	Full Moon
26th	7 PM	Saturn 3°S of Moon
27th	7 PM	Mercury 4°N of Spica
29th		m.p. 20 Massalia 0.6°N of M1 (Neb) in Taurus
29th	3:28 PM	Last Quarter Moon
30th	8 AM	Jupiter 4°S of Moon
31st	10 PM	Venus in inferior conjunction

All times are AEST. For daylight saving add 1 hour.



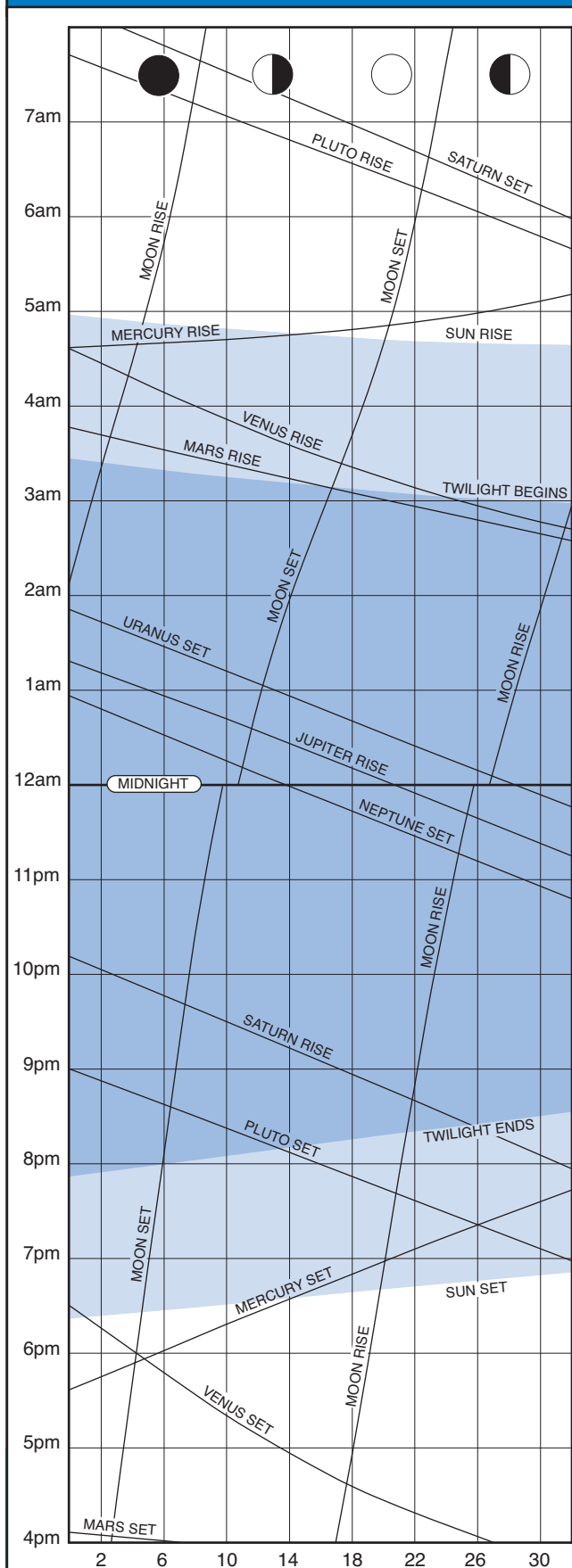


All times are AEST. For daylight saving add 1 hour.



NOVEMBER

RISE/SET CHART



All times are AEST. For daylight saving add 1 hour.

NOVEMBER HIGHLIGHTS

- Venus returns to the morning sky
- Venus, Spica and Mars form a triangle in the morning sky
- Venus and Mars close

THE MOON

- 1st Occultation of minor planet Vesta by the Moon, visible from parts of Northern Hemisphere
- 3rd Occultation of minor planet Juno by the Moon, visible from South America
- 4th Moon at perigee (closest to Earth – 358,154 km distant, angular size 33.9')
- 5th New Moon
- 12th First Quarter
- 16th Moon at apogee (furthest from Earth – 405,796 km distant, angular size 29.8')
- 20th Full Moon. Penumbral Lunar Eclipse, not visible from Australia (see p. 83)
- 28th Last Quarter
- 29th Occultation of minor planet Vesta by the Moon, visible from Western Australia. During the occultation, the Moon is below the horizon from the eastern states.

APPEARANCE of the PLANETS

MERCURY

Mercury is in superior conjunction on the 14th

5th Nov
dia 4.82"
mag -1.1

15th Nov
dia 4.65"
mag -0.9

25th Nov
dia 4.69"
mag -0.8

MARS

15th Nov
dia 3.92"
mag 1.8

SATURN

15th Nov
dia 20.23"
mag -0.3

15th Nov
dia 3.53"
mag 5.8

URANUS

JUPITER

15th Nov
dia 38.59"
mag -2.2

15th Nov
dia 2.25"
mag 7.9

NEPTUNE

15th Nov
dia 0.10"
mag 13.9

PLUTO

THE PLANETS

MERCURY is in superior conjunction (Mercury and Earth on opposite sides of the Sun) on the 14th, and then moves east of the Sun into the evening sky. At this conjunction the planet is occulted by the Sun's disk (not exactly observable). The next such conjunction/occultation occurs in May 2007.

VENUS makes its debut as the Morning Star in November following its inferior conjunction last month. In Virgo for the entire month, Venus rises up toward the 1st magnitude star Spica (Alpha Virginis) and Mars and on the 22nd the trio form a neat triangle (see Sky View). By the 30th, Venus and Mars will be 2.6° apart.

MARS has gained sufficient altitude to be easily visible in the morning twilight before sunrise. On the 3rd, the thin lunar crescent appears 4.3° below the planet (see Sky View). After gradually nearing the 1st magnitude star Spica (Alpha Virginis) during the month, Mars will be at its closest at 3° on the 22nd (see Sky View). On the 30th, Mars and Venus will be 2.6° apart.

JUPITER spends the first half of November in Cancer before crossing over into Leo. The 21-day old waning gibbous Moon appears 6.4° from the planet on the 27th (see Sky View).

SATURN rises around 9pm in the eastern evening sky. Since September the planet has been in Orion (near the tip of the hunter's sword), its retrograde motion now swings it back into Taurus, where it remains until May next year. The 17-day old

AUSTRALIA'S FIRST OBSERVATORY

A lot of people, when asked what was Australia's first observatory might answer Sydney, Melbourne, Parramatta or even Tebbutt's (at Windsor, NSW). Although the first observatory was on Dawes Point we are not talking about Sydney Observatory. 'Sydney', and the others mentioned above, didn't come along until the 19th century.

In 1788 the First Fleet arrived in Sydney Cove. On board the *Sirius*, along with Arthur Phillip was a young astronomer, Lieutenant William Dawes. The Board of Longitude, in England, had given Dawes instruments to establish the fledgling colony's observatory.

The purpose of the observatory was to measure the longitude of Sydney, to provide a time service for the colony and to service the maritime needs of the fleet.

Dawes had also been given the task, by the Government Astronomer at the time, Neville Maskeylene, to try and recover Halley's Comet. This would have been the second recovery of the comet, after Halley successfully predicted its previous return. Dawes looked intensely for the comet during 1788, unfortunately he failed to find it.

On arrival in Sydney he immediately set out to build the observatory with the aid of convicts and marines. The building was located where the southern pylon of the Harbour

Bridge now stands and approximately 500 metres from the current Sydney Observatory. Clearing the land was hard work and the structure was finally completed in August 1788. It was a small building; the lower rectangular section was Dawes' living quarters and study. The upper, octagonal shaped room housed the astronomical and meteorological equipment. The instruments included a sextant, a barometer, thermometers, a telescope and an astronomical quadrant. He later added a homemade hydrometer. Astronomical observations were made through a rectangular canvas shutter.

Dawes was a very talented, versatile and respected individual. As well as his astronomical interests, his duties as a marine officer also placed him in charge of engineering and artillery. He even tried his hand at surveying when it turned out the official surveyor for the colony was not very good at his job.

He also had the distinction of being Australia's first (if not official) meteorologist. In 1777 there was a chance discovery of a 182-page book written by Dawes detailing his weather observations. He made 5 to 6 daily recordings of the wind, temperature, rain and barometric pressure as well as his comments.

Dawes was also one of the first, along with Captain Watkin Trench, to attempt a crossing of the Blue Mountains in 1789. They, like many to follow, were driven back by the rugged terrain of cliffs and ravines.



The Dawes Observatory was built onto the side of a rocky outcrop to help stabilise the instruments. The observatory dome was a wooden frame with canvas. It ran on a track with cannon balls. This reproduction can be found at Old Sydney Town (near Gosford, NSW)



Dawes' original tour of duty was for 3 years. After a while he showed interest in applying for a permanent position as the colony's astronomer. Or at least, if he couldn't stay, he pushed for his instruments to remain in Sydney and for someone else to take up the work. Unfortunately he had a falling out with Governor Phillip.

Phillip's gamekeeper had been killed by some Aborigines. Dawes was ordered by Phillip to join a party to put ten natives to death and return their heads in a bag. Dawes believed the gamekeeper had provoked the attack. The expedition was a failure and on returning to Sydney, Dawes told Phillip he would not obey

such an order again. When his application to stay came up for review in 1791, he was told he must apologise to Phillip first. He refused and within a short time he and his instruments were on a ship heading back to England. The observatory was never used again for astronomical observations and quickly fell into disrepair. For a while it was used as a sentry post.

The French explorer, La Perouse, also established a tent observatory in 1788 at Botany Bay. Unfortunately there are no records remaining of any work done there following their loss in a shipwreck.

It would be 30 years before Sir Thomas Brisbane established Australia's next observatory at Parramatta (a western suburb of Sydney).

NOVEMBER

Moon will be 3.7° from the ringed planet on the 22nd (see Sky View).

URANUS and **NEPTUNE** in Capricornus transit the meridian in the early evening.

PLUTO, in conjunction in early December, becomes lost in the evening twilight this month, returning to the morning sky in the new year.

MINOR PLANETS at opposition this month include 5 Astraea on the 10th at magnitude 10.2 in Cetus and 44 Nysa on the 19th at magnitude 9.4 in Taurus.

COMETS

Comet P/1986 A1 (Shoemaker 3) should first become visible to observers this month as it brightens from 14th to 13th magnitude. Around mid-month, the comet is less than two degrees from the Beehive Cluster (M44) in Cancer, rising around midnight.

Comet C/2001 HT50 (LINEAR-NEAT) is a morning object in the constellation of Sextans. Still more than 3 AU from the Sun and Earth, the comet should be around 13th magnitude in brightness.

Comet 116P/Wild 4 can be found in Virgo in the morning sky, rising before dawn and brightening from 14th to 13th magnitude. Around 8th November, Comet Wild 4 is about 0.2° from 4th magnitude Eta Virginis. Ten days later, the comet is less than 2° from 3rd magnitude Gamma Virginis.

Comet P/1992 Q1 (Brewington) is well placed for observation early in the evening, setting around midnight. The 11th magnitude comet spends November residing in Capricornus. Mid-month Brewington is only a few degrees from Neptune.

METEOR SHOWERS

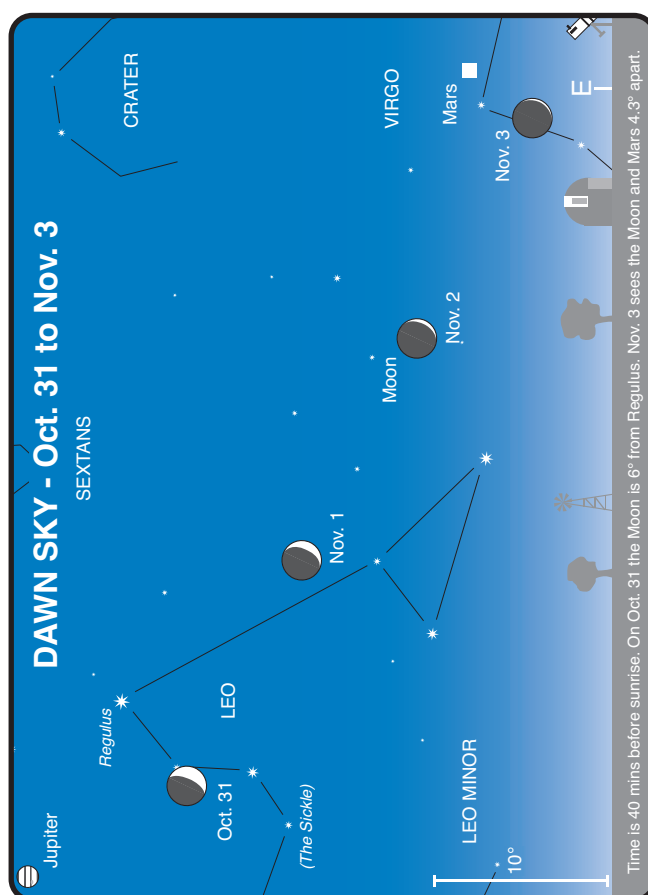
The **Taurids (North and South)** are associated with the short period Comet 2P/Encke, and can be seen from late evening to early morning. The shower is composed of a main double radiant, north and south. They are visible from 1st October through to 25th November. The Taurids do not have a well defined sharp peak in activity, but rather plateau for about ten days in early November. Maxima occurs on the 5th November for the Taurids South (Zenith Hourly Rate of 5) and on the 12th November for the Taurids North (ZHR of 5). Both maxima last for about a week and provide nearly constant ZHRs. The Taurids are frequently bright, slow moving, and noted for producing colourful fireballs. The International Meteor Organisation recommends the Taurids to newcomers. This allows them to practice their visual meteor plotting techniques, because of their slow speed and steady activity. Their brightness also makes them an ideal target for astrophotography.

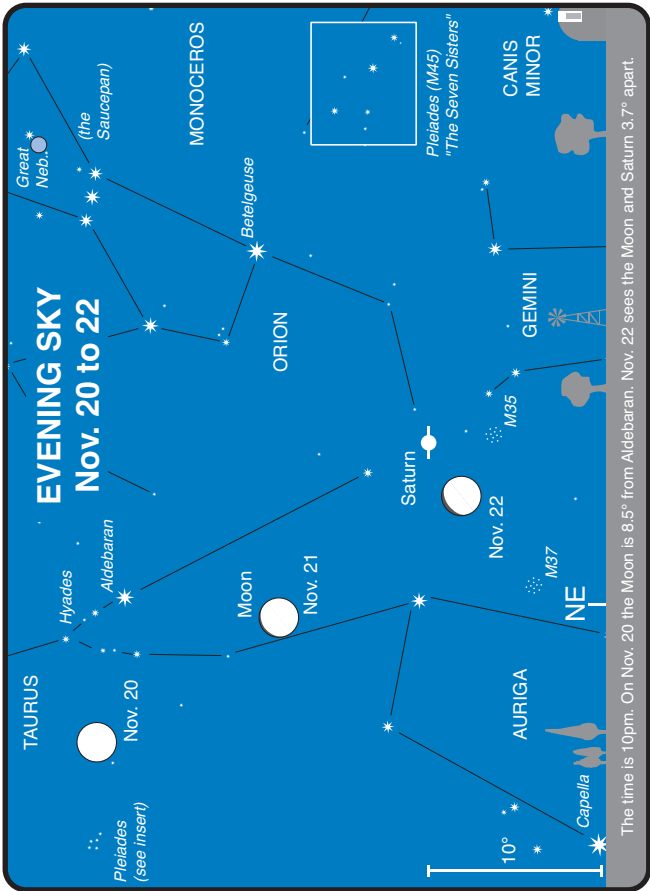
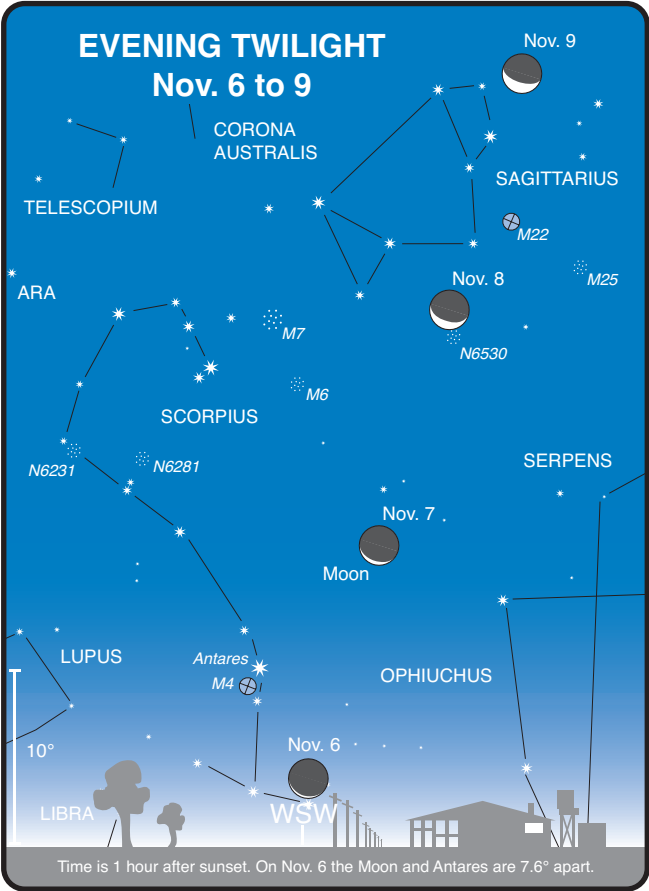
DIARY

1st	10 AM	Vesta 1.3°S of Moon; occultation
3rd	4 AM	Mars 4°S of Moon
3rd	10 PM	Juno 0.6°N of Moon; occultation
4th		Mars 0.7°SW of NGC 4691 (SG) in Virgo
4th	11 AM	Moon at perigee
4th	10 PM	Uranus stationary
5th	6:34 AM	New Moon
9th		m.p. 25 Phocaea 0.3°N of star Theta Aquilae
11th	8 AM	Neptune 5°N of Moon
11th		Mars 0.3°SW of NGC 4941 (SG) in Virgo

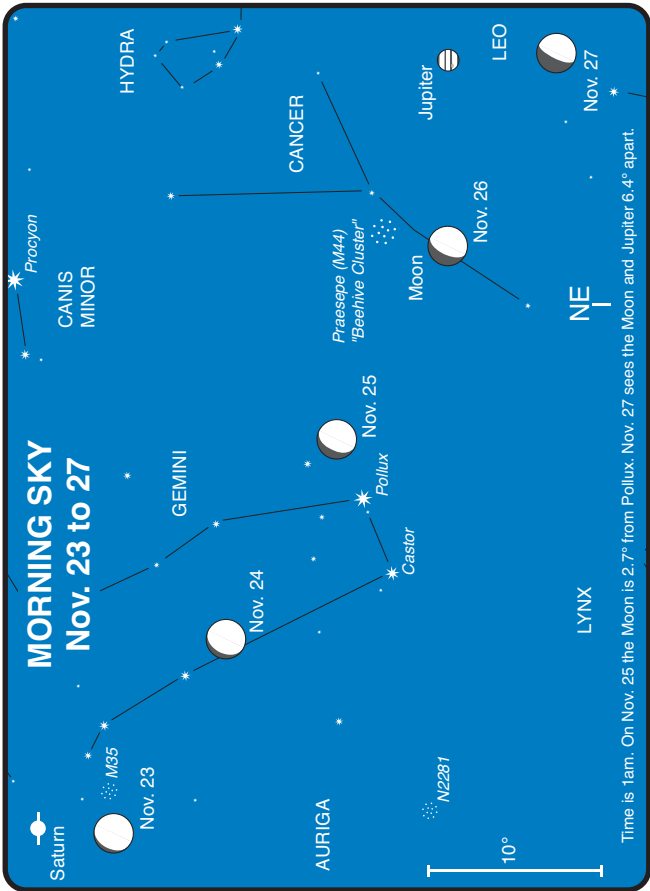
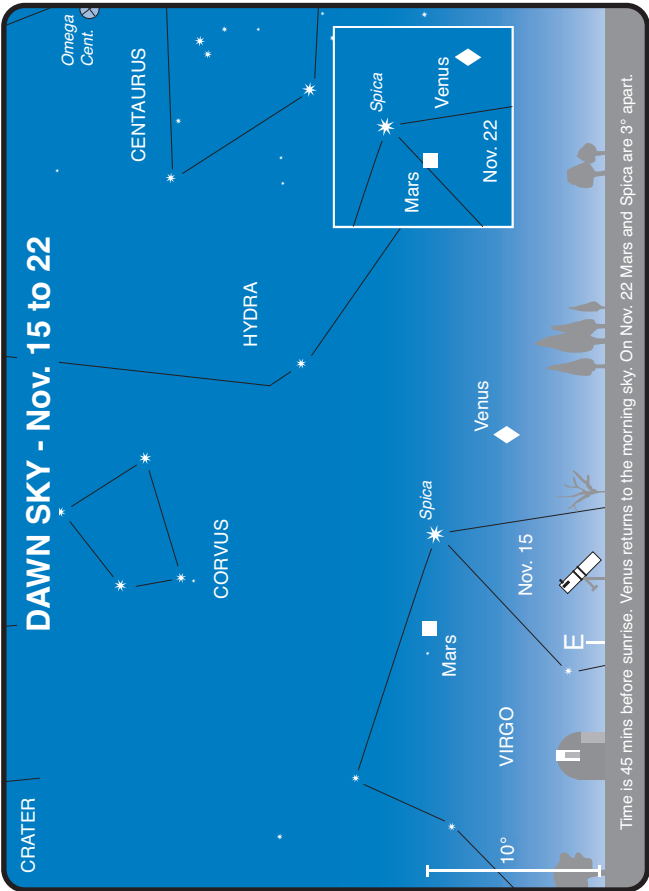
12th	6:52 AM	First Quarter Moon
12th	3 PM	Uranus 5°N of Moon
13th		Mercury at descending node
14th	3 PM	Mercury in superior conjunction
15th		Comet 46P/Wirtanen 0.7°SW of NGC 4365 (EG) in Virgo
15th		Saturn 0.3°N of Berk 21 (OC) in Orion
16th	9 PM	Moon at apogee
19th	2 PM	Venus stationary
20th	11:34 AM	Full Moon; penumbral eclipse
20th	3 PM	Mars 3°N of Spica
22nd	10 PM	Saturn 3°S of Moon
23rd		Mercury at aphelion
24th		Venus at ascending node
24th		m.p. 6 Hebe 0.7°N of M75 (GC) in Sagittarius
26th	5 PM	Jupiter 4°S of Moon
28th	1:46 AM	Last Quarter Moon
29th	1 PM	Vesta 0.04°N of Moon; occultation
30th	4 AM	Ceres stationary

All times are AEST. For daylight saving add 1 hour.



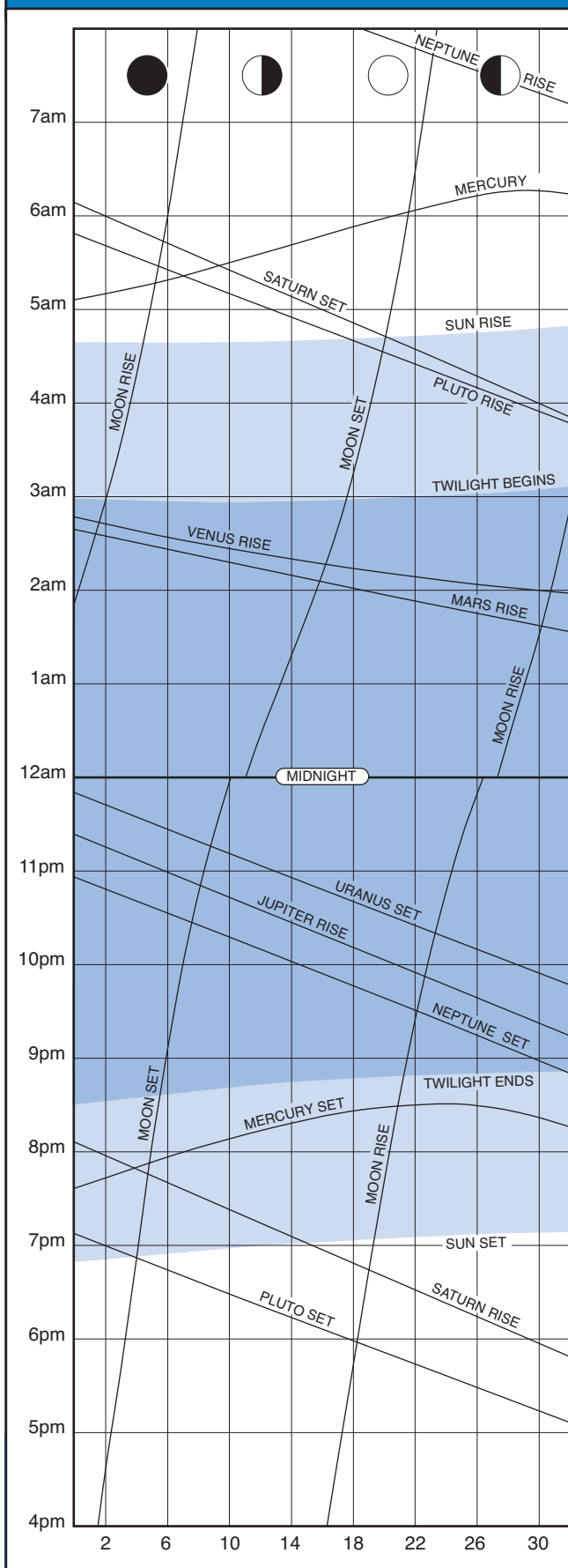


All times are AEST. For daylight saving add 1 hour.



DECEMBER

RISE/SET CHART



All times are AEST. For daylight saving add 1 hour.

DECEMBER HIGHLIGHTS

- Total Solar Eclipse visible from Australia
- Mercury and crescent Moon close
- Venus at its brightest in the morning sky
- Venus and Mars very close
- Saturn at opposition
- Saturn close to the Crab Nebula (M1)

THE MOON

- 2nd Moon at perigee (closest to Earth – 362,289 km distant, angular size 32.7')
- 4th New Moon. Total Eclipse of the Sun, visible from Australia (see article starting page 13).
- 12th First Quarter
- 14th Moon at apogee (furthest from Earth – 404,914 km distant, angular size 29.5')
- 20th Full Moon
- 27th Last Quarter
- 30th Moon at perigee (closest to Earth – 367,902 km distant, angular size 32.9')

APPEARANCE of the PLANETS

MERCURY



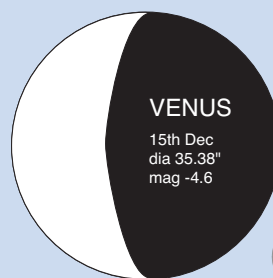
5th Dec
dia 4.92"
mag -0.6



15th Dec
dia 5.45"
mag -0.6



26th Dec
Gt Eastern
Elongation
dia 6.71"
mag -0.5



VENUS

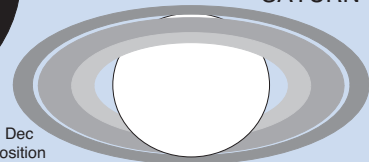
15th Dec
dia 35.38"
mag -4.6

MARS



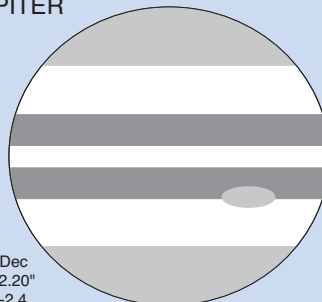
15th Dec
dia 4.29"
mag 1.6

SATURN



18th Dec
Opposition
dia 20.64"
mag -0.5

JUPITER



15th Dec
dia 42.20"
mag -2.4

URANUS

15th Dec
dia 3.45"
mag 5.9

NEPTUNE

15th Dec
dia 2.22"
mag 8.0

PLUTO

15th Dec
dia 0.10"
mag 13.9

THE PLANETS

MERCURY reaches its greatest elongation east of the Sun (20°) on the 26th. This evening apparition is not a particularly good one, although Mercury will be easily seen in the twilight. On the 5th, the very slender 25-hour old crescent Moon will be 2° above and northwards of the planet. An unobstructed western horizon will be required to view Mercury and the Moon, as they set an hour after the Sun.

VENUS rises around 2.30am in Virgo, moving onto Libra half way through the month. In the first week of December, Venus is at its brightest in the morning sky for the next six months (magnitude -4.7). On the 2nd, the 27-day old crescent Moon is 3.6° from the planet (see Sky View). At month-end the waning crescent Moon again is nearby the planet, on the 30th, at 7.3° separation and on the following evening at 6.2° (see Sky View). Venus and Mars remain within 2° of each other between the 2nd and 14th, closest approach of 1.5° occurs on the 7th (see Sky View).

EARTH, at Solstice on the 22nd, marks when the Southern Hemisphere days are longest. On this day at noon, the Sun is at its most southerly position with a declination of -23.5° .

MARS is in the morning sky, rising about an hour before the start of dawn. During December it is never more than 4.7° from Venus and begins the month in Virgo and follows the brighter planet into Libra mid-month. These two planets are closest at 1.5° apart on the 7th (see Sky View). The crescent Moon is near Mars twice during the month, on the 2nd at 5.3° apart (see Sky View), and on the 30th at 4.6° separation (see Sky View).

JUPITER rises around 10pm mid-month. Its trip into Leo last month is short lived when it returns to Cancer on the 15th. On the 23rd, the 19-day old gibbous Moon will be 5° from the planet (see Sky View). Jupiter is at opposition in early February next year, and the period from December through March will

provide the best evening viewing of this the largest of the planets.

SATURN reaches opposition this month on the 18th, visible the whole night. The warm summer evenings are an ideal time to observe this most exquisite planet at its brightest and largest this year. Overall the planet's size has increased by 25% since conjunction. The distance along the length of the rings is 47 arc seconds, and the minor axis is at its widest at 21 arc seconds, slightly broader than Saturn's polar diameter. The Full Moon appears 3.6° from the planet on the 19th (see Sky View). During the month Saturn moves directly toward the Crab Nebula. First in Messier's catalogue, the Crab Nebula or M1 is the remnant of the supernova of 1054AD. This is the second such approach this year, the other in July, occurred in the cold early morning hours. By the 31st the planet will be less than 0.4° from M1, and on the 5th January 2003 the pair are closest at just 0.03° . At this time M1 will be a little closer to the planet than Saturn's moon Titan!

URANUS and **NEPTUNE** are both moving toward solar conjunction early next year, and this month is the last chance to sight the pair in the evening sky.

PLUTO, at conjunction on the 10th, returns to the morning sky in the new year.

MINOR PLANETS at opposition this month include 20 Massalia on the 10th at magnitude 8.7 in Taurus and 349 Dembowska on the 1st at magnitude 9.7 in Taurus. 4 Vesta visits the Virgo cluster of galaxies in December and January.

COMETS

Comet P/1986 A1 (Shoemaker 3) reaches perihelion on 15th December at 1.8 AU from the Sun. The 13th magnitude comet is visible for most of the night, rising late in the evening. During the first half of December, Comet Shoemaker 3 is only a

WHY IS THE SKY BLUE?

This is a fascinating question that children love to ask their parents. The then supposed, all seeing, all knowing grown-ups realise they have been shot down in flames. They have no idea why! There are a few legends around such as the sky reflects the colour of the ocean. This doesn't work very well because the sky is just as blue even if you are in a desert thousands of miles from the nearest ocean. Anyway, why should the ocean be blue in the first place when the water, like the air is clear? (a future topic?). Not only is the sky blue but the Sun, which from space looks white, is slightly yellow when viewed from the ground. CAUTION never look directly at the Sun.

Anyone who has ever looked at a rainbow, or played with a prism, will know that light is made up of a continuous spectrum i.e., violet then blue, green, yellow, orange and red. The closer to the blue end the shorter the wavelength of the light. The oxygen and nitrogen molecules in the atmosphere (which make up 99% of the air) will readily scatter the higher energy, higher frequency, short wavelength blue end of the spectrum, in all directions. That is why when you look at part of the sky, away from the Sun, you see the light as blue. These bundles of energy before finally ending their existence in your eyes have been through a somewhat tortured, convoluted path through the atmosphere. The effect of this scattering is accentuated when the Sun is low in the sky, such as at sunrise or sunset. The sunlight needs to travel through a much thicker atmosphere and the air molecules and dust particles now

scatter nearly all the light leaving only the longest wavelength light to make the direct trip, making the Sun look red.

This atmospheric effect can be simulated by a simple experiment. All you need is an aquarium, a torch, a card with a hole and some milk. Add a few drops of milk to the water and shine the torch through the card and into the tank. Please ensure the tank contains only water, we are not sure how well fish would like a change to a milk diet! As an alternative you could use a glass casserole dish or similar. Position the light so that it shines through the length of the tank. The milk particles will simulate the effect of the air molecules in the atmosphere. The more drops of milk the more yellow, yellow/red and finally red will the direct light appear. Looking in the tank from the sides, at the scattered light, you may see a blue tinge.

Why is Mars different? It is true that the blue sky effect would apply to any planet that has a clear atmosphere of roughly Earth's size and density. However, as NASA's Mars Pathfinder and Viking landers showed, the sky on Mars is a strange mixture of pink, orange and gray. This is because the light scattering is not dominated by air (which for Mars is carbon dioxide). The atmosphere on Mars is very thin and the scattering is mainly caused by suspended dust particles, which are reddened by iron oxide. A similar effect is seen on Earth when we see the brilliant red sunsets when there has been a volcanic eruption or a local bush fire. In this case, the level of dust particles in the air is much higher than normal.

DECEMBER

few degrees away from the planet Jupiter. By mid-month, the comet has moved from the constellation of Cancer into neighbouring Leo.

Comet C/2001 HT50 (LINEAR-NEAT) should brighten from 13th to 12th magnitude this month. Moving from Sextans into Hydra, the comet is now rising before midnight. Around mid-December, LINEAR-NEAT is less than three degrees from 2nd magnitude Alpha Hydrae. The comet reaches perihelion in July of 2003.

Comet 116P/Wild 4 reaches perihelion next month at 2.2 AU from the Sun, and should be around 13th magnitude for all of this month, though it is still a morning object. Around mid-December, Comet Wild 4 is about three degrees from 1st magnitude Spica (Alpha Virginis).

Comet P/1992 Q1 (Brewington) brightens from 11th to 10th magnitude this month as it approaches perihelion in February 2003. Visible only in the evening sky, the comet is less than 3 degrees from 4th magnitude Iota Capricorni in early December. Around the middle of the month, Brewington is less than 4 degrees from Uranus. By month's end, the comet has moved from Capricornus into Aquarius and is less than two degrees from 4th magnitude Theta Aquarii.

METEOR SHOWERS

The **chi-Orionids** are active from 26th November through to 15th December. Their peak is on December 2nd, with a low zenith hourly rate of 3. While generally a weak stream visually, a number of bright meteors have been recorded.

The **Phoenicids** are a southern shower that was discovered in 1956, when a zenith hourly rate of around 100 was observed. There have been three minor bursts in activity since 1956, but in recent years the shower seems nonexistent. There is a possibility that this may be a periodic shower, so observations should still be carried out in case of a return. The period of activity appears to be 28th November through 9th December; with the 6th being the maximum.

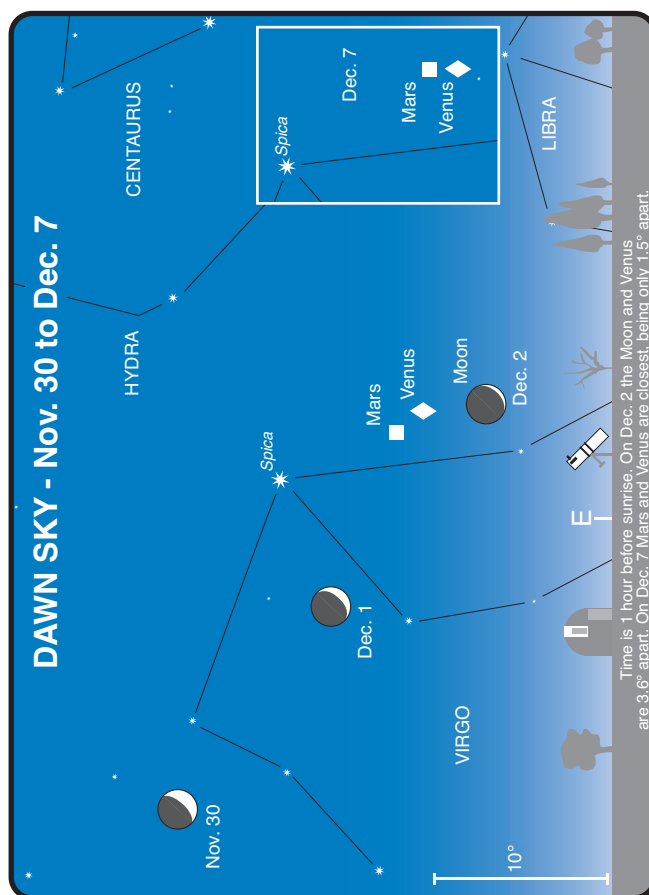
The **Geminids** are one of the best annual showers observable, but for southern observers the radiant is below or close to the horizon until after midnight. Visible from the 7th to 17th, with maximum on the 14th, the Geminids produce often bright, medium speed meteors. The zenith hourly rate is variable but around 110 is normal, and worth watching for in the morning hours, even though our northern counterparts will see the best of the Geminids.

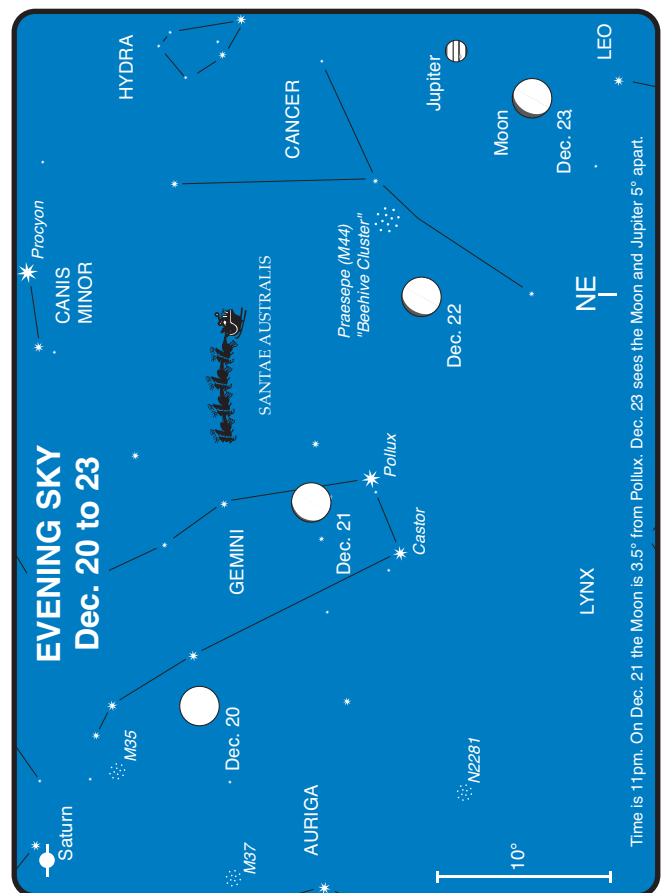
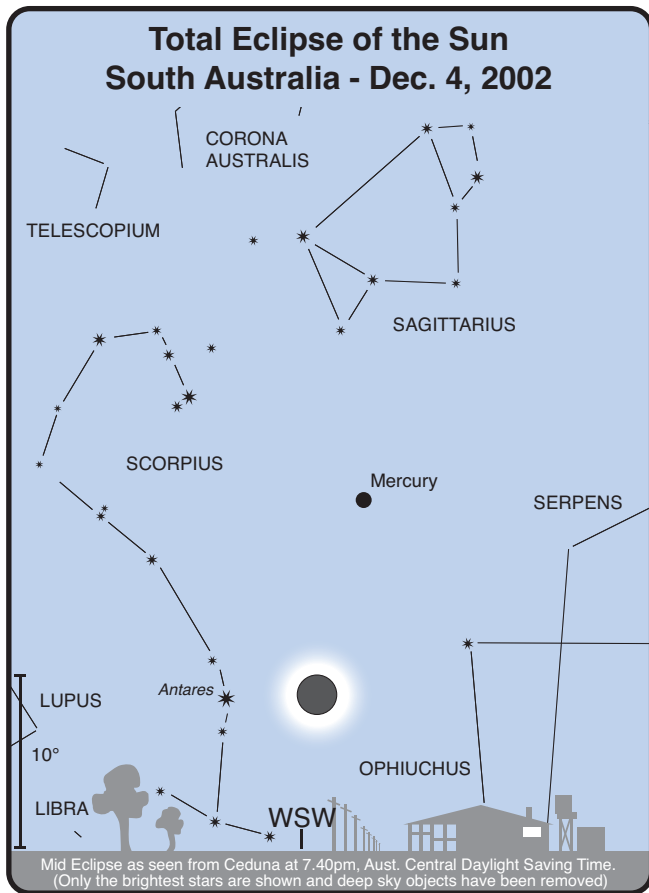
DIARY

1st	8 PM	Mars 3°S of Moon
1st	11 PM	Venus 2°S of Moon
2nd	7 PM	Moon at perigee
4th	5:34 PM	New Moon; eclipse
4th	10 PM	m.p. 1 Ceres 0.5°W of NGC 157 (SG) in Cetus
5th	7 AM	Jupiter stationary
7th		Comet 22P/Kopff 0.1°N of M21 (OC) in Sagittarius
7th	11 AM	Venus greatest brilliancy
8th	6 PM	Neptune 5°N of Moon
9th	Midnight	Uranus 5°N of Moon
10th	3 AM	Pluto in conjunction with Sun
10th		Mercury 0.3°NE of NGC 6553 (GC) in Sagittarius
12th	1:49 AM	First Quarter Moon
12th		Mercury 0.7°S of M28 (GC) in Sagittarius

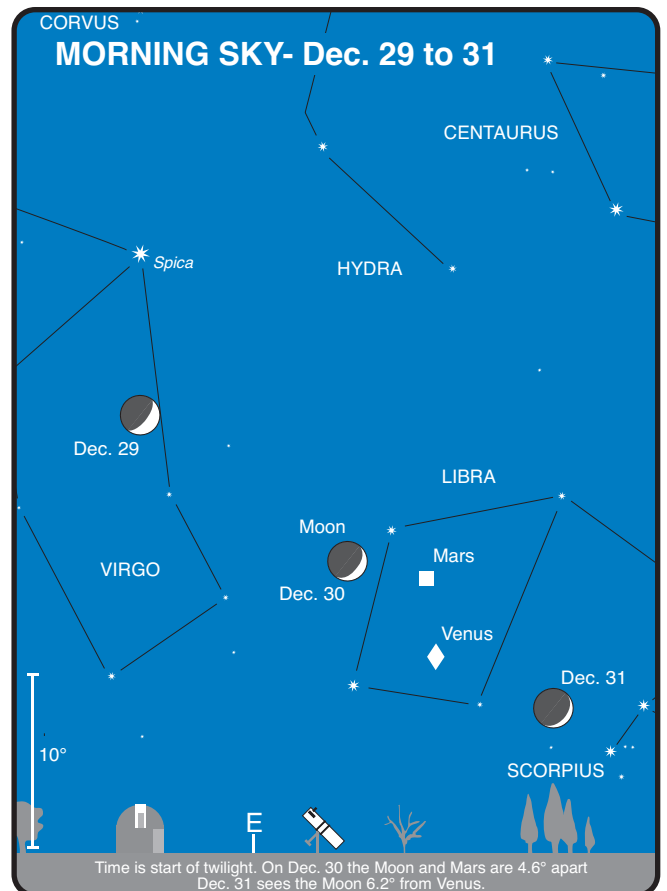
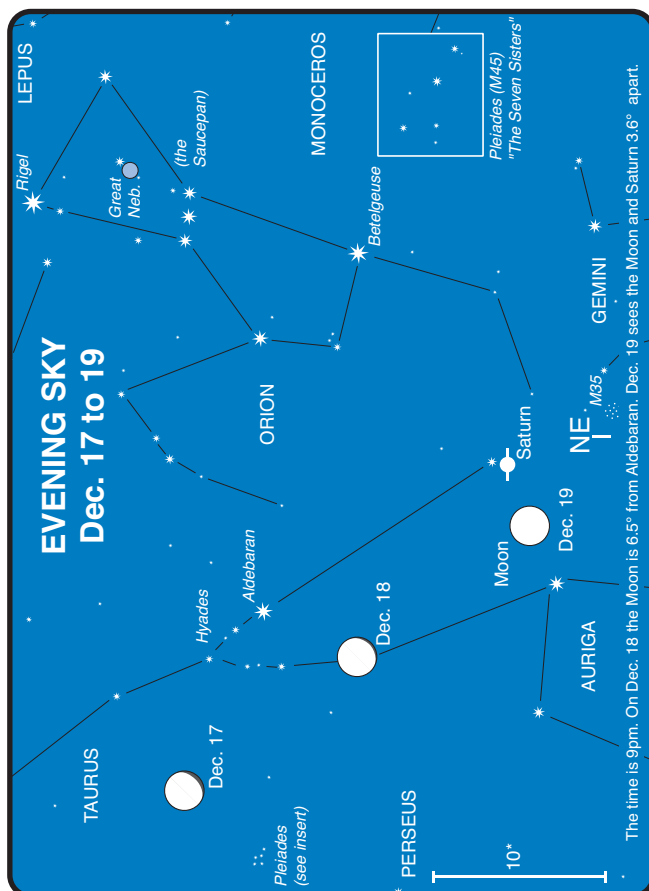
13th		Mercury at greatest latitude South
13th		Mercury 0.1°W of NGC 6638 (GC) in Sagittarius
14th	2 PM	Moon at apogee
14th	9 PM	m.p. 25 Phocaea 0.1°W of M2 (GC) in Aquarius
18th	3 AM	Saturn at opposition
19th	3 AM	Venus 0.1°N of m.p. 9 Metis
20th	1 AM	Saturn 3°S of Moon
20th	5:10 AM	Full Moon
21st		m.p. 4 Vesta 0.1°S of M61 (SG) in Virgo
22nd	11 AM	Solstice
23rd	10 PM	Jupiter 4°S of Moon
25th		Mars 0.4°N of star Alpha 2 Librae
25th		Venus 0.4°NE of NGC 5803 (SG) in Libra
26th		m.p. 2 Pallas 0.8°N of star Beta Aquarii
26th	3 PM	Mercury greatest elongation E (20°)
27th		m.p. 4 Vesta 0.4°N of NGC 4457 (SG) in Virgo
27th	10:31 AM	Last Quarter Moon
28th	9 PM	m.p. 25 Phocaea 0.2°N of star Alpha Aquarii
29th		m.p. 4 Vesta 0.1°SW of NGC 4496A (SG) in Virgo
29th		Venus 0.4°E of NGC 5883 (SG) in Libra
30th	11 AM	Mars 1.2°S of Moon; occultation
30th	11 AM	Moon at perigee
30th	7 PM	Venus 2°N of Moon

All times are AEST. For daylight saving add 1 hour.





All times are AEST. For daylight saving add 1 hour.



PART II

THE SOLAR SYSTEM

GENERAL COMMENTS

Time. There are three time zones used in Part II of this book. They are Australian Eastern Standard Time (AEST) as used in Part I, Australian Central Standard Time (ACST) and Universal Time (UT). ACST is used only for data which has been specifically generated for Adelaide or Darwin e.g., the rise and set times (see the individual Sun, Moon and planet sections) and lunar occultation tables for these cities.

The 24 hr clock is often used in astronomy e.g., 16:00 hr is the same as 4:00pm. This avoids having to distinguish between 'am' and 'pm'. The 24hr approach is used a lot in Part II of this book, e.g., for rise/set times. In some areas, it is convenient to use decimal hours. e.g., 5.3hr is the same as 5hr 18min or 5:18hr. The satellite data for Saturn, Uranus and Neptune use decimal hours.

Universal Time, or UT, is the mean time for the meridian of Greenwich, England, reckoned from midnight. AEST is 10 hours ahead of UT (ACST is 9.5 hours ahead). For example, midnight UT, or 0 hr, is equal to 10:00hr or 10:00am AEST.

Locations. Rise and set times and lunar occultation data are given for specific cities. The latitudes and longitudes used are:

Adelaide	34° 58' S 138° 38' E	Brisbane	27° 30' S 153° 01' E
Canberra	35° 15' S 149° 08' E	Darwin	12° 23' S 130° 44' E
Hobart	42° 48' S 147° 13' E	Melbourne	37° 50' S 145° 00' E
Sydney	33° 54' S 151° 15' E	Townsville	19° 16' S 146° 48' E

Astronomical Co-ordinates or Positions. The astronomical positions are given as equatorial co-ordinates. These are Right Ascension (RA) and Declination (Dec) which are analogous to longitude and latitude for finding places on the Earth. RA is the longitude component but, unlike its terrestrial counterpart, it is not measured in degrees, but in hours. The 360 degrees, for once around the sky, are divided into 24 one hour divisions. Each hour is further divided, like a clock, into minutes and seconds. Declination is the counterpart to latitude but does not use north or south. Instead, objects north of the celestial equator have positive (+) declinations, south are negative (-).

The Earth's daily rotation on its polar axis causes the stars to appear to rotate around a point in the sky. From southern latitudes, including Australia, this point is called the South Celestial Pole and is at declination -90°. The Northern Celestial Pole, not visible from the southern hemisphere, is at +90°. The celestial equator and poles can be described as projections on the sky of their terrestrial counterparts.

Position Tables. Right Ascension and Declination have been calculated for 0 hr UT on the date listed (Epoch 2000.0). All positions are geocentric. This means they have been calculated for a position at the centre of the Earth. There is no allowance for the parallax effect of the observer being on the surface of the Earth. Except for the Moon, this slight shift is insignificant. Positions for the outer planets are given in weekly intervals and correspond to Saturdays; those for the Sun, Moon, Venus and Mercury are daily.

Rise and Set Times. The rise and set times for various objects are given in AEST, except Adelaide and Darwin which use ACST (see above). The times given are when the upper limb of the object is coincident with the theoretical horizon. The data is adjusted for atmospheric refraction. The intervals used for rise/sets are weekly, the dates correspond to Saturdays. The exception is the Moon which is presented for each day.

Use of Star Atlases. As the Earth orbits the Sun, the polar axis remains fixed relative to the stars. The points, around which the stars appear to rotate (the celestial poles), appear to never change no matter what time of the year one is observing. However, the positions of the celestial poles do slowly move against the star field. This is called precession and is caused by the Earth's axis slowly wobbling, like a spinning top, over thousands of years.

'Epoch 2000.0' refers to an object's position relative to where the celestial poles (+/-90° in declination) were in the year 2000.

Field of View in a Telescope. All the satellite diagrams and finder charts in this book are drawn to correct or normal sky orientation, i.e., east to the left, and north to the top (in the sky, east and west are opposite to what is seen on terrestrial maps). Telescope systems that use an odd number of reflecting surfaces will mirror (or reverse) the image. The common use of star diagonals in Schmidt-Cassegrains or traditional refractors causes this reversal. Binoculars or straight Newtonians show 'normal' sky images (the Newtonian image will be upside down).

Finder Charts. No finder charts are presented for the Moon, Venus or Mercury. Their rapid motion during the year causes them to cover a very large section of the sky which is difficult to cater for adequately in the space available. Considering how bright these objects are, the Sky View diagrams (see Part I) should be sufficient to act as finders.

SECTION EXPLANATION

The following is a brief explanation of the information in Part II of this book. Some sections are not mentioned here, or only briefly described, when more detailed discussions are presented on the relevant pages.

Declinations of the Sun and Planets (p. 76) In general, the further south a planet is (negative declination), the higher in the northern sky it is, as seen from Australia. The higher in the sky, the less atmosphere you have to look through and the more stable the image is (less prone to turbulence). This can be particularly relevant when trying to observe a planet under high magnification.

Planetary Angular Size (p. 76) The vertical axis of this diagram is in arc seconds. 2002 presents an interesting challenge. For those keen sighted observers, there is a chance to view the thin crescent of Venus with the unaided eye. This year Venus gets to 1 arc minute in size during the time of inferior conjunction at the end of October. This is when the planet is closest to the Earth and the time Venus passes between us and the Sun (also see the diagram on p. 79). This event happens about every 580 days. It is only near this time that Venus shows a thin crescent. No matter what size Venus presents it is certainly worthwhile trying to observe it using binoculars (it helps to keep the binoculars steady by using a tripod). Looking during twilight can often help. There is less glare and the planet is higher in the sky. See Part I for the expected crescent shapes for Mercury and Venus.

Planet Magnitudes (p. 77) The magnitude plot of Mercury is not shown when the planet is near inferior conjunction as it is too close to the Sun and little of the bright side of the planet can be seen from Earth.

Meridian Passage of the Sun and Planets (p. 77) The time of meridian passage for a planet is when it is due north and at its highest point in the sky. For the outer planets this is certainly looked upon as the best time to observe when you are looking through the least amount of atmosphere. The time for the Sun is close to midday (12hrs). When a planet crosses from the bottom of the diagram (0 hours) to the top (24 hours) it is at opposition and visible the whole night.

Planet Illumination (p. 78) This graph gives an indication of how much of the planet's disc, visible from Earth, is lit by the Sun. A figure of 100% means the whole disc is bright, presenting a 'full moon' like appearance; 50% would be like a first (or third) quarter Moon. The inner planets show the largest change in phase. For example, as Mercury approaches inferior conjunction (directly between the Sun and the Earth), the phase shrinks as more of the night side becomes visible. It is obvious from the drawing that Mercury will reach inferior conjunctions in January, May and September. □ **Planetary Elongation from the Sun** (p. 78). This is an indication of how far the planet is away from the Sun in degrees. When it is close to zero the planet is in conjunction with the Sun, not a good time to go looking for the planet. When it is near 180° it is close to opposition and visible the whole night. It doesn't tell

you whether it is in the morning or evening sky but the Visibility of the Planets diagram (p. 23) shows that easily.

Moon - Rise/Set Times (pp. 84-87). Looking at this data you will see there are some days where the Moon does not rise or set (represented by 'DNR' for Does Not Rise, or 'DNS' for Does Not Set). The reason for this lies in the Moon's rapid daily motion from west to east. Consecutive days show the Moon to rise (or set) more than 24 hours later. Hence, if the Moon rises just before midnight on the 1st of the month, it may not rise again until after midnight on the 2nd. Therefore it becomes an event for the 3rd of the month with no event on the 2nd.

JUPITER AND SATURN

Jupiter - Longitudes of Central Meridian. (p. 103) Unlike Mars, Jupiter (and Saturn) are gas giants and they only allow us to view their upper atmospheric features. Only a small telescope (even a 50mm instrument) is required to view the equatorial belts and the Great Red Spot. When seeing is good, numerous breaks can be glimpsed in the bands as well as many minor spots. There is no single correct rotation period for the features of Jupiter. The speed of movement of any feature on the 'surface' depends on its latitude, hence the multiple rotation systems used. To monitor the movement and development of any feature, amateurs often measure the time a feature crosses the central meridian of the planet.

The longitude can be worked out from the Longitude of Central Meridian tables. All the times on the main tables are calculated for 0hrs UT (10:00am AEST) of date. You will need to add multiple hours and minutes from the small 'Increase in Longitude' tables. For example the longitude of central meridian for Jupiter (system I) for November 1 at 2:20am AEST would be calculated as follows. First subtract 10 hours to convert to UT i.e., 16:20 hrs on October 31. From the table, the longitude on October 31 is 192.4° . To this add an adjustment for the 16 hours, which is 225.3° , and finally for the 20 mins add 12.2° . These add up to 429.9° ; less 360° gives a final answer of 69.9° .

Jupiter's Moons (pp. 104-109). Jupiter is like a miniature solar system with many moons orbiting the planet. Also, like the planets, these moons all lie in a similar plane. This plane is also very close to that of the Earth's orbit. Therefore, as seen from Earth, the moons appear to move from side-to-side (east-west) of Jupiter, occasionally passing across (transiting) or behind (occulted by) the planet. The diagrams (pp. 107-109) show the patterns the four major moons of Jupiter make as they move from side-to-side. Each complete period represents one orbit of the satellite. The close pair of parallel vertical lines, running down the centre, represents the disc of Jupiter. It is interesting to compare the times when each moon passes over these lines, with the satellite's transit times (pp. 105-106). The same can be done with the occultation times, that is when the line disappears behind Jupiter.

The four moons Io, Europa, Ganymede and Callisto are bright enough to be seen in binoculars (7X power or greater is recommended). It may be necessary to mount the binoculars on a tripod to help keep them steady. Initially, try looking for Callisto when it is furthest from Jupiter (maximum elongation). This happens every 8 days approximately; an example would be the evening of January 26. To see the moons, with binoculars, may take a little practice. The power or magnification of the binoculars will determine how close to Jupiter you can follow a moon. Of course, with a small telescope you would have no problem following the moons and their shadows as they cross the disc of Jupiter. Watching a moon fade and disappear as it moves into Jupiter's shadow (an eclipse) is very impressive.

Eclipse Positions of Jupiter's Moons (bottom of p. 104) shows the positions of the eclipse events for each satellite for mid-month, relative to Jupiter. An eclipse is when the moon passes into (disappearance or 'd') or out of (reappearance or 'r') Jupiter's shadow.

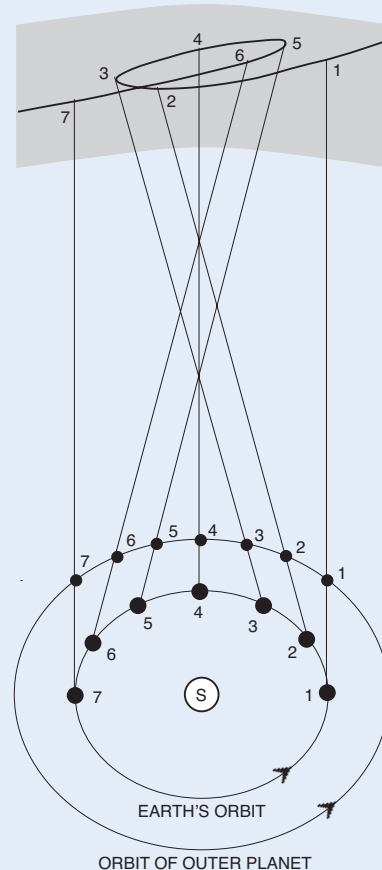
RETROGRADE MOTION

The finder charts for the outer planets have one thing in common - an apparent motion with a loop shape. This only applies to the period during opposition. (Note Mars does not reach opposition every year). The diagram below illustrates the combined effects of the orbital motions of Earth and an outer planet to explain this loop.

In the diagram, the shaded area represents the path of an outer planet against the celestial sphere. As the Earth moves around the Sun, faster than this outer planet (let's call it Uranus), our home planet overtakes it. The result is this loop or S-bend in the apparent path against the celestial sphere. This apparent reversal in the planet's movement is known as retrograde motion, and at this time the planet moves from east to west instead of from west to east.

At positions 1 and 2, Uranus continues its west to east path and begins to slow to position 3 as the Earth catches up. Between 3 and 5, Uranus is in retrograde motion (i.e., moving east to west) and it is at opposition (in line with the Earth and the Sun) at 4. At points 3 and 5, the planet is said to be stationary. After 5, as the Earth passes the slower planet, Uranus continues its west to east direction.

Because the orbits of the outer planets are inclined to that of the Earth's, the path can never be a straight line. It will always be a loop or an S-bend.



Jupiter's Moons - Mutual Events (p. 106). It has already been stated above that the plane of Jupiter's moons is close to that of the Earth's orbit. About every 6 years the two planes cross and for a brief period we can see the moons eclipse and occult each other. The drop in brightness does not just depend on the relative magnitudes of the satellites. It also varies depending on whether the event is complete e.g., how much of the shadow (eclipse) or the moon (occultation) covers the other moon during an event.

Saturn's Rings. (p. 112) The 'Appearance of the Planets' diagrams in Part I show how open the rings are for 2002. The plane of the rings is tilted, with respect to the plane of the ecliptic, by 28° . The planet's year is 29.5 Earth years. During this period the Earth can be up to 28° above or below the plane of the rings. Every 7 years, after each of these maximum ring openings, the Earth passes through the plane of the rings and they are seen as edge-on. The rings were edge-on during 1995. During 2002, the rings are wide open.

Satellites of Saturn (pp. 112-113). To estimate the configuration or positions of the satellites, the Apparent Orbits diagram and the times of Greatest Eastern Elongation are needed. For each satellite, take the previous (most recent) date of greatest eastern elongation and work out the period that has elapsed (in days and hours) since

this time. Locate this time on the relevant orbit on the diagram and that gives the moon's position directly.

URANUS, NEPTUNE AND PLUTO

Satellites of Uranus (p. 115). Titania (III) and Oberon (IV) are the easiest to observe visually. However, at least a 20cm telescope, under dark skies, is needed to glimpse these distant bodies. The inner satellites, Ariel and Umbriel, are harder to observe and they would be a real test for a 40cm telescope. The orbits of the satellites are only partly open as seen from Earth. The orbits' apparent minor axis (running east/west) is 36% of the apparent major axis (north/south). For example, Oberon, at opposition, has a maximum elongation of 44' (p. 75). Its minimum elongation would be 36% of this or 16'. To locate the approximate position angle (degrees east of north) for a satellite, at your time of observation:

1. Work out how long since the satellite's most recent greatest northern elongation.
2. Express this as a fraction of the sidereal orbital period. Satellites I, II, III, and IV have periods of 2.52, 4.14, 8.71 and 13.46 days respectively.
3. Multiply the result by 360°.

Satellite of Neptune (p. 115). With typical amateur telescopes, Triton (I) is the only observable moon. To find Triton, use the approach as described above for the satellites of Uranus. Note that in this case, the apparent major axis is in the east/west direction. The orbits of the Neptunian satellites are currently relatively open. In 2002, Triton's apparent orbit as seen from Earth is an ellipse with the minor axis being 74% of the major axis. Therefore Triton, at opposition, varies from 17' (p. 75) down to 13'. To find the approximate position angle of Triton, the same approach is used as

above for Uranus. The sidereal orbital period for Triton is 5.88 days and after step 3 add 90° to get the position angle from north. If greater than 360°, subtract 360°.

Pluto (pp. 118-119). The pointer chart is designed to help people find the general area for Pluto. The main finder chart shows stars down to approximately magnitude 14.5. This is necessary to pick out the faint star-like image of Pluto (magnitude 13.7) from other numerous faint stars in the field. Commonly available star atlases do not include stars down to anywhere near this magnitude.

Minor Planets (pp. 120-121). As well as the 9 planets, their moons and the comets, the Solar System contains numerous smaller bodies known as the minor planets or asteroids. There are now tens of thousands of such bodies catalogued! Most of these are found in the asteroid belt between the orbits of Mars and Jupiter. The majority of these objects are extremely faint and difficult to observe. Many can be found by photographing the area, at least twice, over several days and detecting them as they move against the distant star field. The same can be achieved by observing the field and making drawings over several days to detect which star has moved. Be sure you have the right field of view! Only about 60 of these bodies can be considered bright (by amateur standards) and most of them only around their time of opposition. The ephemerides are for the 20 brightest minor planets that reach opposition during 2002. These selected asteroids all get brighter than, or close to, 10th magnitude around the time of opposition.

SOLAR SYSTEM DATA — THE PLANETS

NAME	MEAN DISTANCE FROM SUN (x 10 ³ km) (Earth = 1)		MAG at OPP	EQUATORIAL DIAMETER (km).	FLATTENING ¹	No of MOONS	MASS (x10 ²⁴ kg) (Earth = 1)	
Sun	-		-26.8	1392530	0	-	1989085	332946
Moon	-		-12.74 ¹¹	3475	0	-	0.073483	0.0123
Mercury	57856	0.387	0.16 ¹²	4879	0	0	0.33022	0.055
Venus	108132	0.723	-4.07 ¹²	12104	0	0	4.8690	0.816
Earth	149492	1.000	-3.5 ¹³	12756	0.00335364	1	5.9742	1.000
Mars	227780	1.524	-2.01	6794	0.006476	2	0.64191	0.107
Jupiter	777776	5.203	-2.70	142984	0.064874	28 ¹⁵	1898.8	317.900
Saturn	1425983	9.540	0.67	120536	0.097962	30 ¹⁵	568.50	95.200
Uranus	2867760	19.180	5.52	51118	0.022927	20 ¹⁵	86.625	14.500
Neptune	4492800	30.700	7.84	49528	0.017081	8	102.78	17.400
Pluto	5745000	39.670	13.7	2302	0	1	0.015	0.003
NAME	VOLUME (Earth = 1)	SIDEREAL PERIOD ²	SYNODIC PERIOD (days) ³	AXIAL ROTATION (days) ⁴	ALBEDO ⁵	ECCEN- TRICITY ⁶	INCLINATION ⁷	OBLIQUITY ⁸
Sun	1300000	-	-	25.38 ⁹	-	-	-	7° 15' ¹⁰
Moon	0.02	27.32 d	29.4	27.32166	0.12	0.0549	5° 08' 40"	6° 41'
Mercury	0.06	87.97 d	115.8	58.6462	0.106	0.20562	7° 00' 00"	0° 00'
Venus	0.86	224.7 d	583.9	-243.0187	0.65	0.00681	3° 23' 38"	92° 00'
Earth	1	365.256 d	-	0.99726968	0.367	0.01681	0° 00' 00"	23° 26'
Mars	0.15	687 d	779.8	1.02595675	0.150	0.09333	1° 51' 01"	25° 10'
Jupiter	1323	11.86 y	398.8	0.41354 ¹⁴	0.52	0.04837	1° 18' 28"	3° 07'
Saturn	752	29.46 y	378.0	0.44401 ¹⁴	0.47	0.05582	2° 29' 29"	26° 45'
Uranus	64	84.01 y	369.7	-0.71833	0.51	0.0471	0° 46' 22"	98° 00'
Neptune	54	164.8 y	367.5	0.67125	0.41	0.00855	1° 46' 38"	29° 00'
Pluto	0.007	249.9 y	366.7	-6.3872	0.30	0.2486	17° 09' 00"	118° 00'

- Notes: 1 The ratio of the difference of equatorial and polar radii to equatorial radius.
2 The planet's year.
3 The period of the planet's orbit with respect to the Earth.
4 The planet's day. A negative sign indicates the rotation is retrograde with respect to the North pole.
5 The ratio of the sunlight reflected to that received.
6 The measure of how long or thin the ellipse of the planet's orbit is.
7 The angle of the planet's orbit from the plane of the ecliptic.
8 The degree of inclination of the planet's equator to its orbit

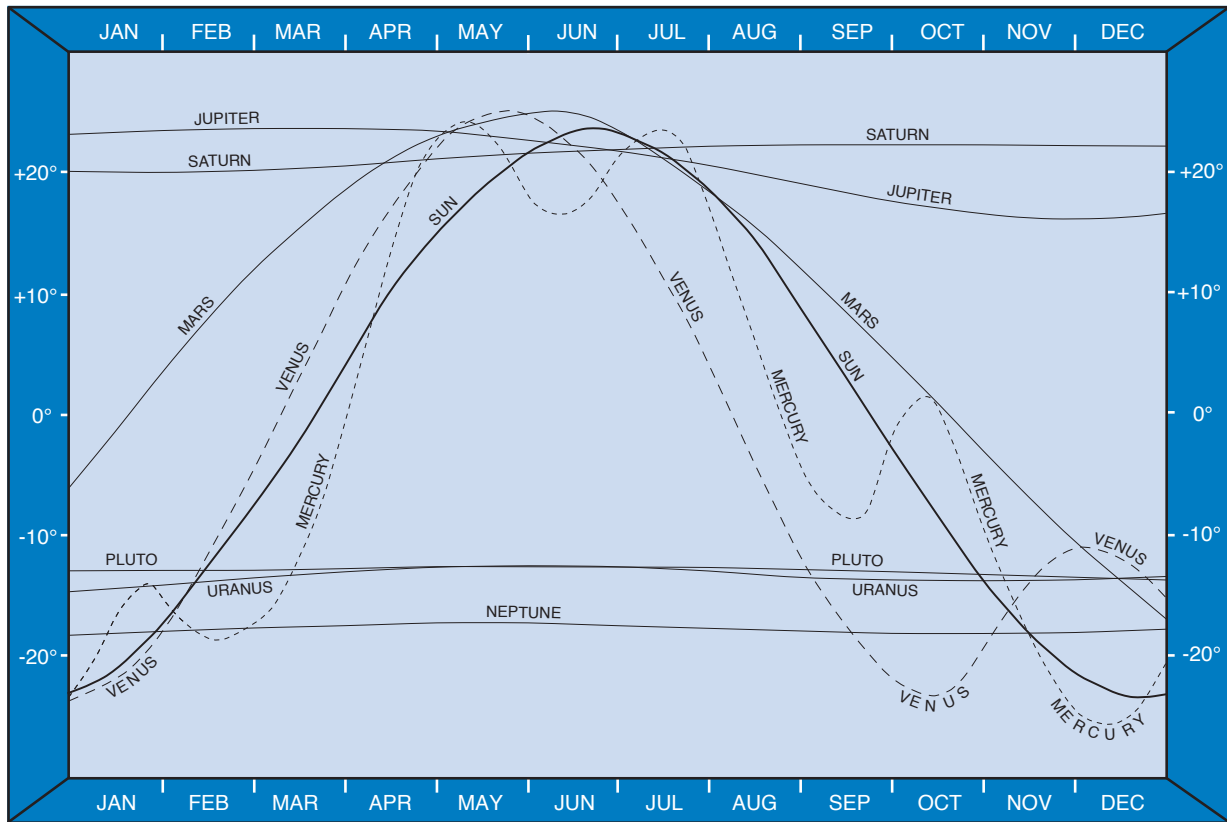
- 9 Equatorial region (the polar areas of the Sun rotate in a period of 29 to 30 days).
10 To the ecliptic.
11 From the Earth.
12 At mean greatest elongation.
13 As seen from the Sun.
14 Based on System III rotation. Similar to systems I or II except a radio source within the planet is used as the reference point.
15 There have been a number of recent discoveries with new satellites not yet named or their orbits fully determined.

SOLAR SYSTEM DATA — SATELLITES

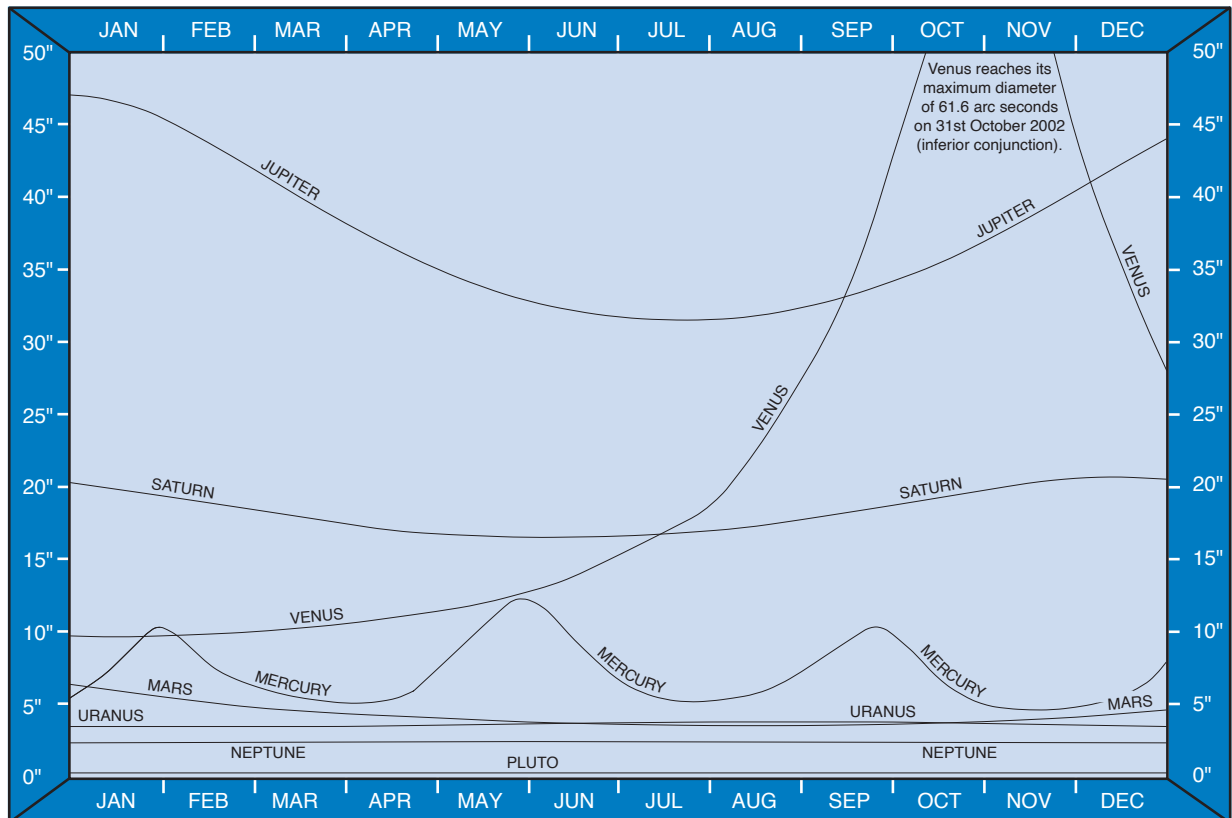
PLANET	SATELLITE	ORBITAL ¹ PERIOD (days) (R=retrograde)	MAX. ELONG AT MEAN OPPOSITION	SEMI-MAJOR AXIS (x10 ³ km)	ORBITAL ECCENTRICITY	INCLINATION TO PLANET'S EQUATOR (°)	MASS (1/PLANET)	RADIUS (km)	SIDEREAL PERIOD OF ROTATION (days) ⁴	MAGNITUDE AT OPPOSITION
Earth										
	Moon	27.321661		384.400	0.054900489	18.28-28.58	0.01230002	1737.4	S	-12.74
Mars										
	Phobos I	0.31891023	25"	9.378	0.015	1.0	1.65x10 ⁻⁸	13.4x11.2x9.2	S	11.3
	Deimos II	1.2624407	1' 02"	23.459	0.0005	0.9-2.7	3.71x10 ⁻⁹	7.5x6.1x5.2	S	12.40
Jupiter										
	Metis XVI	0.294780	0' 42"	128			0.5x10 ⁻¹⁰	20	S	17.5
	Adrastea XV	0.29826	0' 42"	129			0.1x10 ⁻¹⁰	13x10.8	S	19.1
	Amalthea V	0.49817905	0' 59"	181	0.003	0.40	38x10 ⁻¹⁰	131x73x67	S	14.1
	Thebe XIV	0.6745	1' 13"	222	0.015	0.8	4x10 ⁻¹⁰	55x45	S	15.7
	Io I	1.769137786	2' 18"	422	0.004	0.04	4.70x10 ⁻⁵	1830x1819x1815	S	5.02
	Europa II	3.551181041	3' 40"	671	0.009	0.47	2.53x10 ⁻⁵	1565	S	5.29
	Ganymede III	7.15455296	5' 51"	1070	0.002	0.21	7.80x10 ⁻⁵	2634	S	4.61
	Callisto IV	16.6890184	10' 18"	1883	0.007	0.51	5.67x10 ⁻⁵	2403	S	5.65
	Leda XIII	238.72	1° 00' 39"	11094	0.14762	26.07	0.03x10 ⁻¹⁰	5		20.2
	Himalia VI	250.5662	1° 02' 46"	11480	0.15798	27.63	50x10 ⁻¹⁰	85	0.4	14.84
	Lysithea X	259.22	1° 04' 04"	11720	0.107	29.02	0.4x10 ⁻¹⁰	12	0.533	18.4
	Elara VII	259.6528	1° 04' 10"	11737	0.20719	24.77	4x10 ⁻¹⁰	40		16.77
	Ananke XII	631. R	1° 55' 52"	21200	0.16870	147	0.2x10 ⁻¹⁰	10	0.35	18.9
	Carne XI	692. R	2° 03' 31"	22600	0.20678	164	0.5x10 ⁻¹⁰	15	0.433	18.0
	Pasiphae VIII	735. R	2° 08' 26"	23500	0.378	145	1x10 ⁻¹⁰	18		17.03
	Sinope IX	758. R	2° 09' 31"	23700	0.275	153	0.4x10 ⁻¹⁰	14	0.548	18.3
Saturn										
	Pan XVIII	0.5750	0' 21"	133.583				10		
	Atlas XV	0.6019	0' 22"	137.670	0.000	0.3		18.5x17.2x13.5		18
	Prometheus XVI	0.6130	0' 23"	139.353	0.003	0.0		74x50x34		16
	Pandora XVII	0.6285	0' 23"	141.700	0.004	0.0		55x44x31		16
	Epimetheus XI	0.6942	0' 24"	151.422	0.009	0.34	9.5x10 ⁻¹⁰	69x55x55	S	15
	Janus X	0.6945	0' 24"	151.472	0.007	0.14	3.38x10 ⁻⁹	97x95x77	S	14
	Mimas I	0.942421813	0' 30"	185.52	0.0202	1.53	6.60x10 ⁻⁸	209x196x191	S	12.9
	Enceladus II	1.370217855	0' 38"	238.02	0.00452	0.00	1x10 ⁻⁷	256x247x245	S	11.7
	Telesto XIII	1.8878	0' 48"	294.66				15x12.5x7.5		18.5
	Tethys III	1.887802160	0' 48"	294.66	0.00000	1.86	1.10x10 ⁻⁶	536x528x526	S	10.2
	Calypso XIV	1.8878	0' 48"	294.66				15x8.8		18.7
	Helene XII	2.7369	1' 01"	377.40	0.005	0.0		18x16x15		18
	Dione IV	2.736914742	1' 01"	377.40	0.002230	0.02	1.93x10 ⁻⁶	560	S	10.4
	Rhea V	4.517500436	1' 25"	527.04	0.00100	0.35	4.06x10 ⁻⁶	764	S	9.7
	Titan VI	15.94542068	3' 17"	1221.83	0.029192	0.33	2.37x10 ⁻⁴	2575	S	8.28
	Hyperion VII	21.2766088	3' 59"	1481.1	0.104	0.43	4x10 ⁻⁸	180x140x113		14.19
	Iapetus VIII	79.3301825	9' 35"	3561.3	0.02828	14.72	2.8x10 ⁻⁶	718	S	11.1
	Phoebe IX	550.48 R	34' 51"	12952	0.16326	177 ²	7x10 ⁻¹⁰	110	0.4	16.45
Uranus										
	Cordelia VI	0.3350338	0' 04"	49.77	0.00026	0.08		13		24.1
	Ophelia VII	0.376400	0' 04"	53.79	0.0099	0.10		15		23.8
	Bianca VIII	0.43457899	0' 04"	59.17	0.009	0.19		21		23.0
	Cressida IX	0.46356960	0' 05"	61.78	0.0004	0.01		31		22.2
	Desdemona X	0.47364960	0' 05"	62.68	0.00013	0.11		27		22.5
	Juliet XI	0.49306549	0' 05"	64.35	0.00066	0.07		42		21.5
	Portia XII	0.51319592	0' 05"	66.09	0.0000	0.06		54		21.0
	Rosalind XIII	0.55845953	0' 05"	69.94	0.0001	0.28		27		22.5
	Belinda XIV	0.62352747	0' 06"	75.26	0.00007	0.03		33		22.1
	Puck XV	0.76183287	0' 07"	86.01	0.00012	0.32		77		20.2
	Miranda V	1.41347925	0' 10"	129.39	0.0027	4.2	0.08x10 ⁻⁵	240x234x233	S	16.3
	Ariel I	2.52037935	0' 14"	191.02	0.0034	0.3	1.55x10 ⁻⁵	581x578x578	S	14.16
	Umbriel II	4.1441772	0' 20"	266.30	0.0050	0.36	1.35x10 ⁻⁵	585	S	14.81
	Titania III	8.7058717	0' 33"	435.91	0.0022	0.14	4.06x10 ⁻⁵	789	S	13.73
	Oberon IV	13.4632389	0' 44"	583.52	0.0008	0.10	3.47x10 ⁻⁵	761	S	13.94
	Caliban XVI	579R	8' 56"	7,169	0.082	139.7 ²		30		22.4
	Sycorax XVII	1289R	15' 26"	12,214	0.509	152.7 ²		60		20.9
Neptune										
	Naiad III	0.294396	0' 02"	48.23	0.000	4.74		29		24.7
	Thalassa IV	0.311485	0' 02"	50.07	0.000	0.21		40		23.8
	Despina V	0.334655	0' 02"	52.53	0.000	0.07		74		22.6
	Galatea VI	0.428745	0' 03"	61.95	0.000	0.05		79		22.3
	Larissa VII	0.554654	0' 03"	73.55	0.00139	0.20		104x89		22.0
	Proteus VIII	1.122315	0' 06"	117.65	0.0004	0.55		218x208x201	S	20.3
	Triton I	5.8768541 R	0' 17"	354.76	0.000016	157.345	2.09x10 ⁻⁴	1353	S	13.47
	Nereid II	360.13619	4' 21"	5513.4	0.7512	27.6 ³	2x10 ⁻⁷	170		18.7
Pluto										
	Charon I	6.38725	<1"	19.6	<0.001	99 ³	0.125	593	S	16.8

Notes: 1 - Sidereal periods, except tropical periods are given for Saturn. 2 - Relative to the ecliptic plane. 3 - Referred to the equator of 1950.0
4 - S = Synchronous, rotation period same as orbital period. i.e., keeps the same section of its surface facing its planet.

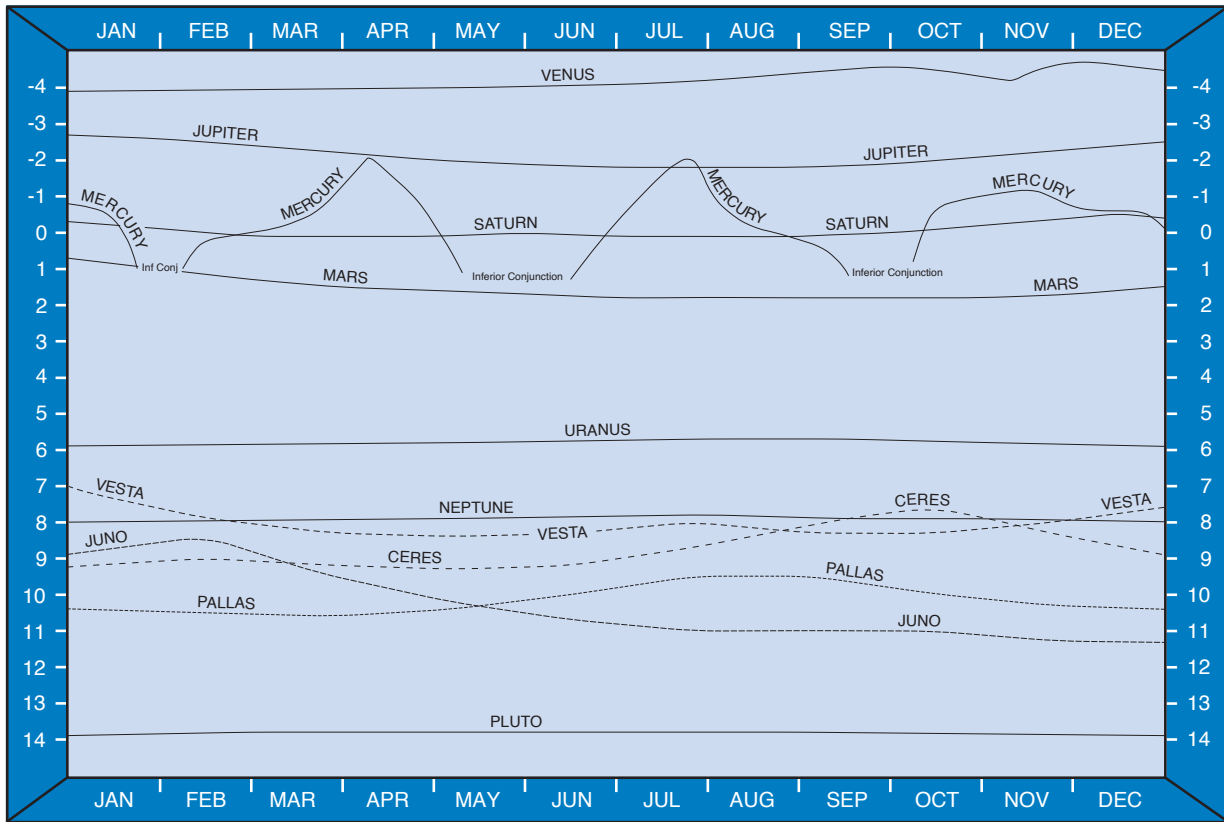
DECLINATIONS of the SUN and PLANETS



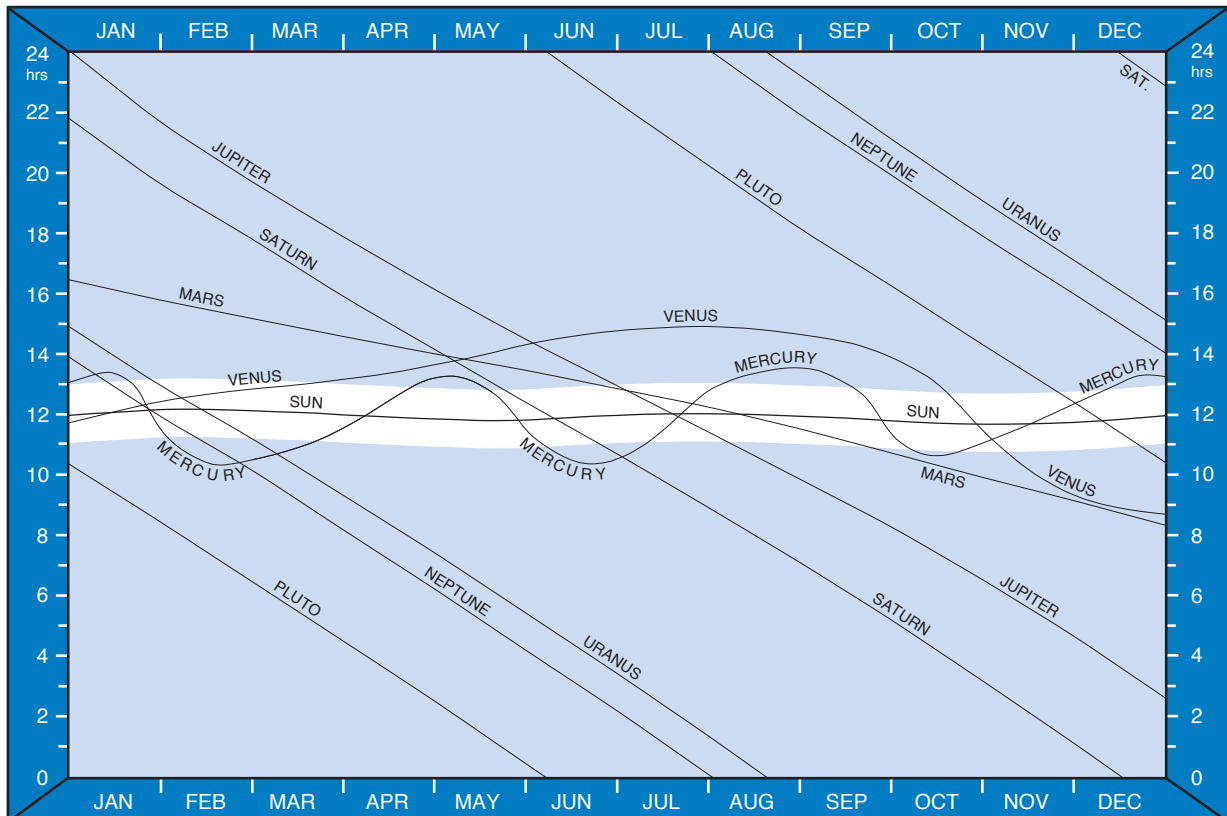
PLANETARY ANGULAR SIZE



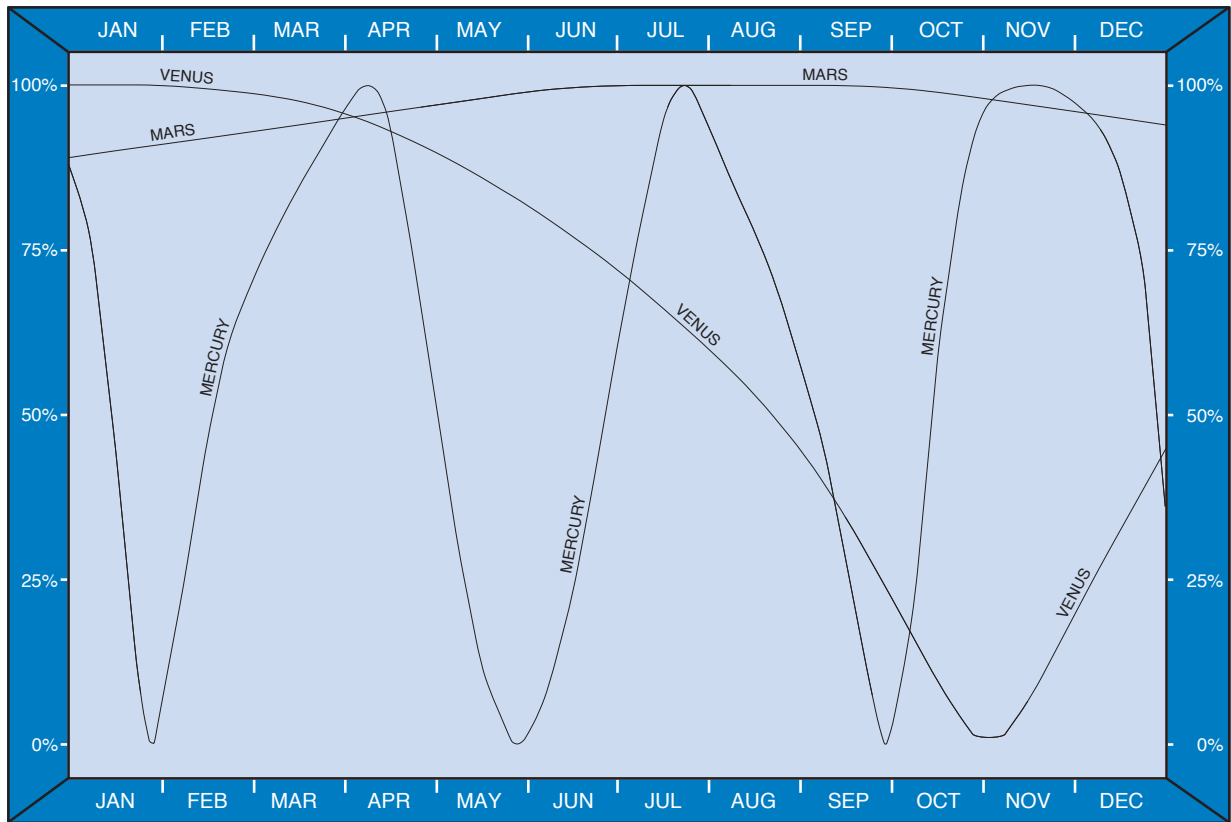
MAGNITUDES of the PLANETS and MAJOR ASTEROIDS



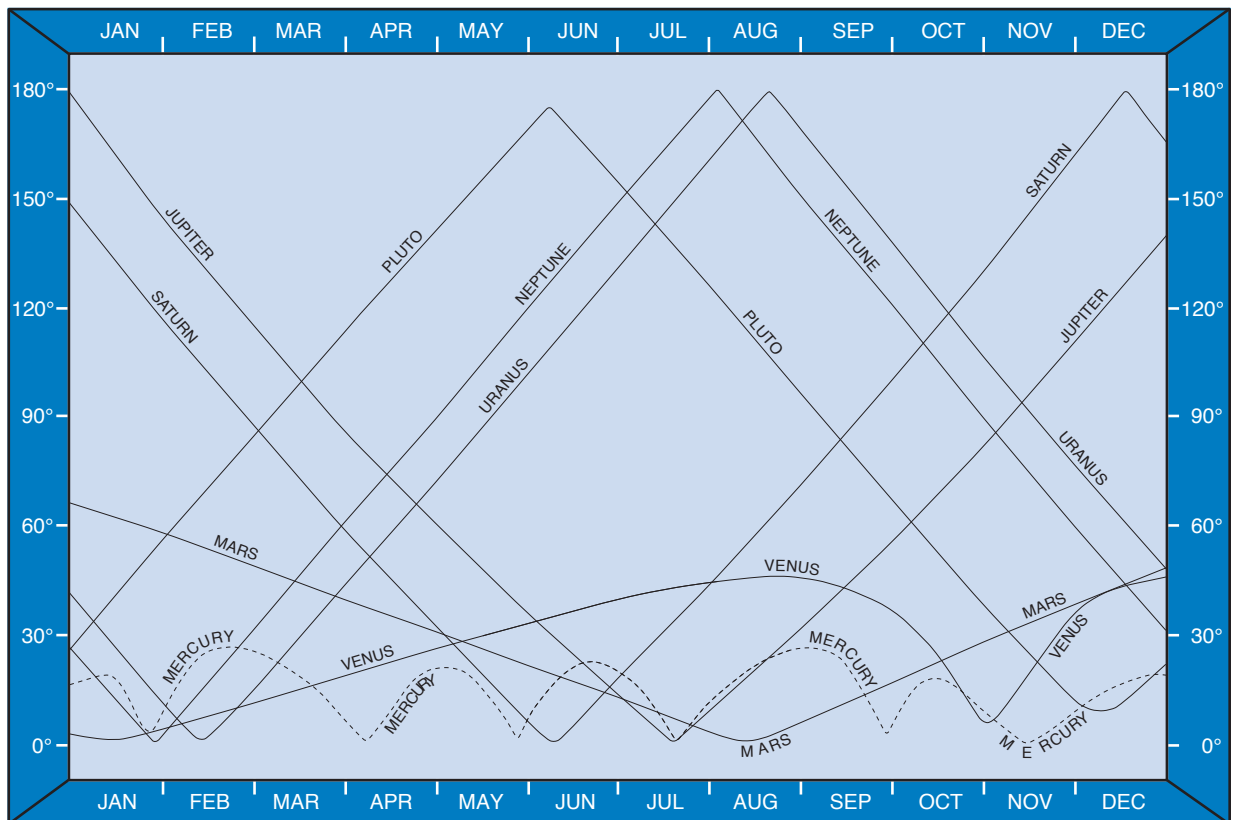
MERIDIAN PASSAGE of the SUN and PLANETS



PLANET ILLUMINATION

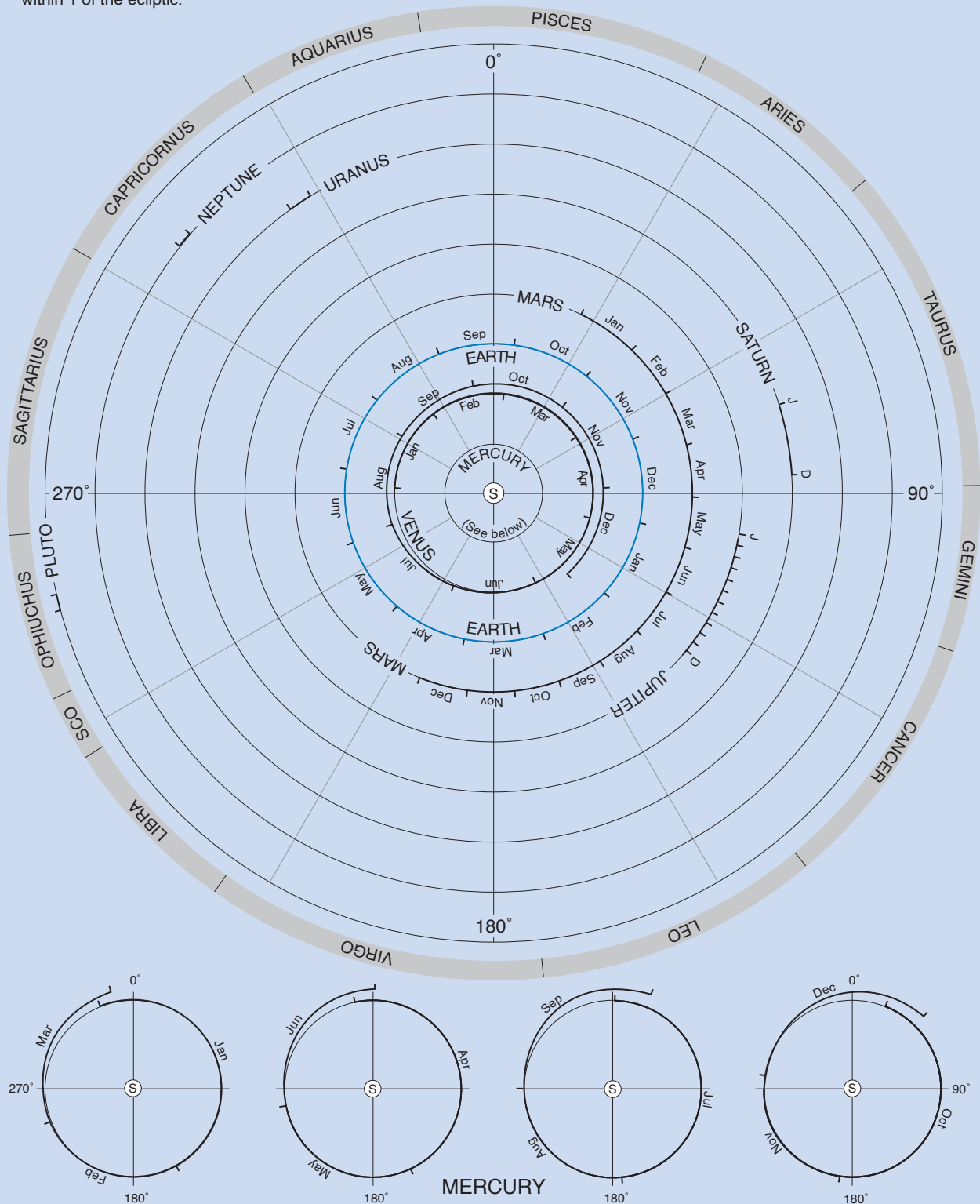


PLANET ELONGATION from the SUN



PLANET POSITIONS

This diagram illustrates the relative positions of the planets during the course of their orbits in 2002. The relationship between the major solar system bodies is clearly shown. For example, this year's opposition of Jupiter occurs very early in January when the Earth appears closest. A line extended from Earth, through and beyond Jupiter shows that the planet is located in Gemini at this time. The diagram is drawn as viewed from below (south of) the solar system. The drawing has been simplified in that the planetary orbits are not shown as ellipses and the distances are not drawn to scale. The thirteen constellations named are those that are situated on the ecliptic. If a planet is off the ecliptic it may in fact be in a neighbouring constellation, Saturn for instance appears in Orion from September to mid-November, whereas our diagram indicates Taurus during this period. A small section of Orion comes within 1° of the ecliptic.



SUN RISE, SUN SET AND ASTRONOMICAL TWILIGHT

AEST (Adelaide & Darwin ACST)

		ADELAIDE				BRISBANE				CANBERRA				DARWIN					
		TWI	SUN	TWI	TWI	TWI	TWI	TWI	SUN	TWI	TWI	SUN	TWI						
		BEG	RISE	SET	END	BEG	RISE	SET	END	BEG	RISE	SET	END	BEG	RISE	SET	END		
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m		
Jan	5	03:22	05:08	19:33	21:18	03:27	04:59	18:48	20:19	03:09	04:55	19:22	21:08	05:09	06:27	19:17	20:35	Jan	5
	12	03:31	05:14	19:33	21:16	03:33	05:04	18:48	20:18	03:17	05:01	19:21	21:05	05:13	06:31	19:19	20:36		12
	19	03:40	05:21	19:31	21:12	03:40	05:10	18:47	20:16	03:26	05:08	19:19	21:01	05:18	06:35	19:20	20:36		19
	26	03:49	05:28	19:27	21:06	03:48	05:15	18:45	20:12	03:36	05:16	19:16	20:55	05:23	06:38	19:20	20:35		26
Feb	2	03:59	05:35	19:22	20:58	03:55	05:21	18:42	20:07	03:46	05:23	19:11	20:47	05:27	06:41	19:19	20:34	Feb	2
	9	04:09	05:43	19:16	20:49	04:02	05:26	18:37	20:01	03:56	05:30	19:05	20:38	05:30	06:44	19:18	20:31		9
	16	04:18	05:50	19:09	20:40	04:09	05:32	18:32	19:54	04:05	05:37	18:57	20:29	05:33	06:46	19:15	20:28		16
	23	04:27	05:56	19:01	20:30	04:15	05:36	18:26	19:47	04:14	05:44	18:49	20:19	05:36	06:48	19:12	20:24		23
Mar	2	04:35	06:03	18:52	20:19	04:21	05:41	18:19	19:39	04:23	05:51	18:40	20:08	05:38	06:49	19:09	20:20	Mar	2
	9	04:43	06:09	18:43	20:09	04:26	05:45	18:12	19:30	04:30	05:57	18:31	19:57	05:39	06:50	19:05	20:15		9
	16	04:50	06:15	18:33	19:58	04:31	05:49	18:04	19:22	04:37	06:03	18:21	19:46	05:40	06:50	19:00	20:11		16
	23	04:56	06:21	18:23	19:48	04:35	05:53	17:56	19:14	04:44	06:08	18:11	19:36	05:40	06:51	18:56	20:06		23
	30	05:02	06:26	18:14	19:37	04:39	05:56	17:48	19:06	04:50	06:14	18:02	19:26	05:41	06:51	18:51	20:02		30
Apr	6	05:08	06:32	18:04	19:28	04:42	06:00	17:41	18:58	04:55	06:20	17:52	19:16	05:41	06:51	18:47	19:57	Apr	6
	13	05:13	06:37	17:55	19:19	04:46	06:03	17:33	18:51	05:01	06:25	17:42	19:07	05:41	06:52	18:43	19:54		13
	20	05:18	06:43	17:46	19:11	04:49	06:07	17:26	18:45	05:06	06:31	17:34	18:59	05:41	06:52	18:39	19:50		20
	27	05:23	06:48	17:38	19:03	04:52	06:11	17:20	18:39	05:11	06:37	17:25	18:51	05:41	06:53	18:35	19:47		27
May	4	05:28	06:54	17:30	18:57	04:55	06:15	17:14	18:34	05:16	06:42	17:18	18:44	05:42	06:54	18:33	19:45	May	4
	11	05:32	06:59	17:24	18:51	04:58	06:19	17:10	18:30	05:20	06:48	17:12	18:39	05:42	06:56	18:30	19:44		11
	18	05:37	07:05	17:19	18:47	05:01	06:23	17:06	18:27	05:25	06:53	17:06	18:35	05:43	06:57	18:29	19:43		18
	25	05:41	07:10	17:15	18:44	05:05	06:26	17:03	18:25	05:29	06:58	17:02	18:31	05:44	06:59	18:28	19:43		25
Jun	1	05:45	07:14	17:12	18:42	05:07	06:30	17:01	18:24	05:33	07:03	16:59	18:29	05:46	07:01	18:28	19:43	Jun	1
	8	05:48	07:18	17:10	18:41	05:10	06:33	17:00	18:23	05:36	07:07	16:58	18:28	05:47	07:03	18:28	19:44		8
	15	05:51	07:21	17:10	18:41	05:12	06:36	17:01	18:24	05:39	07:10	16:58	18:29	05:49	07:05	18:29	19:45		15
	22	05:53	07:23	17:11	18:42	05:14	06:38	17:02	18:25	05:41	07:12	16:59	18:30	05:51	07:07	18:31	19:47		22
	29	05:54	07:24	17:14	18:44	05:15	06:39	17:04	18:27	05:42	07:13	17:01	18:32	05:52	07:08	18:32	19:48		29
Jul	6	05:53	07:24	17:17	18:47	05:16	06:39	17:06	18:29	05:42	07:12	17:04	18:34	05:53	07:09	18:34	19:50	Jul	6
	13	05:52	07:22	17:21	18:50	05:15	06:38	17:10	18:32	05:41	07:11	17:08	18:38	05:54	07:09	18:36	19:51		13
	20	05:50	07:19	17:25	18:54	05:14	06:36	17:13	18:35	05:38	07:07	17:12	18:42	05:54	07:08	18:38	19:52		20
	27	05:46	07:14	17:30	18:58	05:11	06:33	17:17	18:38	05:35	07:03	17:17	18:46	05:53	07:07	18:39	19:53		27
Aug	3	05:42	07:09	17:35	19:02	05:08	06:28	17:20	18:41	05:30	06:57	17:22	18:50	05:52	07:05	18:41	19:54	Aug	3
	10	05:36	07:02	17:40	19:06	05:04	06:23	17:24	18:43	05:24	06:51	17:28	18:54	05:50	07:03	18:42	19:54		10
	17	05:29	06:54	17:45	19:11	04:58	06:17	17:27	18:46	05:17	06:43	17:33	18:59	05:48	07:00	18:42	19:54		17
	24	05:21	06:46	17:50	19:15	04:52	06:11	17:31	18:49	05:09	06:34	17:38	19:03	05:44	06:56	18:43	19:54		24
	31	05:13	06:37	17:56	19:20	04:46	06:03	17:34	18:52	05:01	06:25	17:43	19:08	05:41	06:52	18:43	19:54		31
Sep	7	05:03	06:27	18:01	19:25	04:38	05:56	17:37	18:55	04:51	06:15	17:48	19:13	05:37	06:47	18:43	19:53	Sep	7
	14	04:53	06:17	18:06	19:30	04:30	05:48	17:40	18:58	04:41	06:06	17:54	19:18	05:32	06:42	18:43	19:53		14
	21	04:43	06:07	18:11	19:35	04:22	05:39	17:43	19:01	04:31	05:55	17:59	19:23	05:27	06:37	18:43	19:53		21
	28	04:32	05:57	18:16	19:41	04:13	05:31	17:47	19:05	04:20	05:45	18:04	19:29	05:22	06:33	18:43	19:53		28
Oct	5	04:21	05:47	18:21	19:47	04:05	05:23	17:50	19:09	04:09	05:35	18:09	19:36	05:17	06:28	18:43	19:54	Oct	5
	12	04:11	05:38	18:27	19:54	03:56	05:16	17:54	19:14	03:58	05:26	18:15	19:43	05:12	06:24	18:43	19:55		12
	19	04:00	05:29	18:33	20:02	03:48	05:09	17:58	19:19	03:47	05:16	18:21	19:51	05:08	06:20	18:44	19:56		19
	26	03:50	05:20	18:39	20:10	03:40	05:02	18:02	19:24	03:37	05:08	18:28	19:59	05:04	06:16	18:45	19:58		26
Nov	2	03:40	05:13	18:46	20:19	03:33	04:57	18:07	19:31	03:27	05:00	18:34	20:08	05:00	06:14	18:47	20:01	Nov	2
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	28	03:15	05:02	19:32	21:18	03:21	04:53	18:45	20:18	03:01	04:49	19:20	21:08	05:04	06:22	19:13	20:32		28

SUN RISE, SUN SET AND ASTRONOMICAL TWILIGHT

AEST

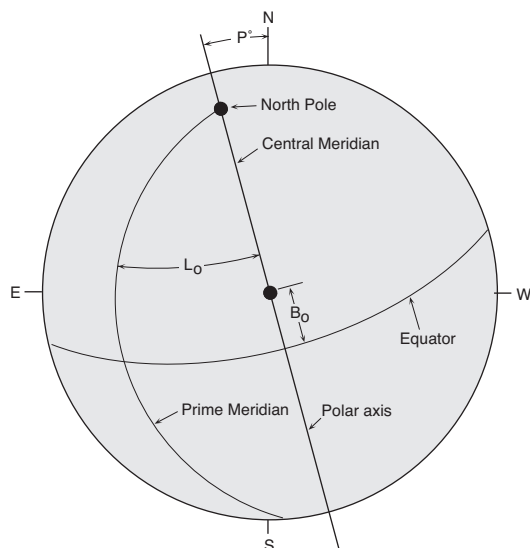
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		TWI	SUN		TWI	TWI	SUN		TWI	TWI	SUN		TWI	TWI	SUN		TWI		
		BEG	RISE	SET	END	BEG	RISE	SET	END	BEG	RISE	SET	END	BEG	RISE	SET	END		
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m		
Jan	5	02:26	04:40	19:53	22:06	03:11	05:04	19:46	21:39	03:07	04:50	19:10	20:53	04:18	05:40	18:55	20:18	Jan	5
	12	02:38	04:47	19:51	22:00	03:20	05:11	19:45	21:35	03:15	04:56	19:10	20:51	04:23	05:45	18:57	20:19		12
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May	4	05:27	07:04	17:11	18:48	05:34	07:03	17:30	18:59	05:06	06:31	17:12	18:37	05:14	06:29	17:50	19:05	May	4
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	28	02:16	04:33	19:52	22:08	03:03	04:58	19:44	21:39	03:00	04:44	19:08	20:52	04:12	05:35	18:53	20:16		28

SUN

GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
	R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "	
1	18 45 06	- 23 02 03		20 57 32	- 17 12 56		22 46 53	- 07 44 38		00 40 41	+ 04 22 41		02 32 03	+ 14 56 54		04 34 48	+ 21 59 43	
2	18 49 31	- 22 57 03		21 01 36	- 16 55 50		22 50 38	- 07 21 50		00 44 20	+ 04 45 50		02 35 52	+ 15 15 02		04 38 54	+ 22 07 50	
3	18 53 55	- 22 51 37		21 05 40	- 16 38 27		22 54 22	- 06 58 56		00 47 58	+ 05 08 53		02 39 42	+ 15 32 54		04 43 00	+ 22 15 33	
4	18 58 19	- 22 45 43		21 09 43	- 16 20 47		22 58 06	- 06 35 56		00 51 37	+ 05 31 51		02 43 32	+ 15 50 32		04 47 06	+ 22 22 54	
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7	19 11 29	- 22 25 20		21 21 47	- 15 26 04		23 09 15	- 05 26 23		01 02 35	+ 06 40 09		02 55 07	+ 16 41 48		04 59 28	+ 22 42 35	
8	19 15 52	- 22 17 39		21 25 46	- 15 07 17		23 12 57	- 05 03 03		01 06 15	+ 07 02 42		02 58 59	+ 16 58 21		05 03 36	+ 22 48 21	
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10	19 24 35	- 22 00 58		21 33 44	- 14 28 59		23 20 20	- 04 16 10		01 13 35	+ 07 47 27		03 06 46	+ 17 30 35		05 11 52	+ 22 58 40	
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13	19 37 36	- 21 32 44		21 45 34	- 13 29 42		23 31 23	- 03 05 28		01 24 37	+ 08 53 34		03 18 31	+ 18 16 44		05 24 19	+ 23 11 08	
14	19 41 55	- 21 22 29		21 49 29	- 13 09 30		23 35 03	- 02 41 49		01 28 19	+ 09 15 20		03 22 28	+ 18 31 31		05 28 28	+ 23 14 28	
15	19 46 13	- 21 11 49		21 53 23	- 12 49 04		23 38 43	- 02 18 08		01 32 01	+ 09 36 56		03 26 24	+ 18 45 59		05 32 37	+ 23 17 23	
16	19 50 31	- 21 00 44		21 57 17	- 12 28 26		23 42 23	- 01 54 26		01 35 43	+ 09 58 22		03 30 21	+ 19 00 07		05 36 46	+ 23 19 54	
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27	20 36 57	- 18 33 42		22 39 22	- 08 29 53		00 22 29	+ 02 25 56		02 16 51	+ 13 42 00		04 14 26	+ 21 13 28		06 22 30	+ 23 20 17	
28	20 41 06	- 18 18 11		22 43 07	- 08 07 19		00 26 08	+ 02 49 24		02 20 38	+ 14 01 05		04 18 30	+ 21 23 27		06 26 39	+ 23 17 51	
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31	20 53 26	- 17 29 43					00 37 03	+ 03 59 28					04 30 43	+ 21 51 13				
	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
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9	07 12 02	+ 22 24 25		09 14 44	+ 15 58 23		11 08 55	+ 05 28 25		12 57 06	- 06 06 08		14 55 39	- 16 44 07		17 02 11	- 22 46 26	
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17	07 44 33	+ 21 15 59		09 44 54	+ 13 33 06		11 37 39	+ 02 25 04		13 26 41	- 09 05 47		15 28 15	- 18 52 37		17 37 28	- 23 20 16	
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19	07 52 36	+ 20 55 13		09 52 20	+ 12 54 33		11 44 49	+ 01 38 39		13 34 10	- 09 49 30		15 36 32	- 19 21 30		17 46 19	- 23 24 06	
20	07 56 36	+ 20 44 17		09 56 03	+ 12 34 57		11 48 24	+ 01 15 23		13 37 56	- 10 11 09		15 40 42	- 19 35 26	</			

ORIENTATION OF THE SUN



P° Position angle of Polar Axis. (+ when pole east of north point, - if west)

B_o° Heliocentric Latitude of centre of Sun

L_o° Heliocentric Longitude of centre of Sun

At the date of commencement of each synodic rotation period the value of L_o is zero; that is, the prime meridian passes through the central point of the disk.

The rotation period of the Sun depends on Latitude. The sidereal period of rotation at the equator is 25.38 days. The mean synodic period is 27.28 days.

SOLAR and LUNAR ECLIPSES

During the year 2002 there are five eclipses, two of the Sun and three of the Moon. One solar eclipse is annular and the other total. The three lunar eclipses are all penumbral.

Magnitudes quoted for lunar eclipses relate to the percentage of the lunar diameter that is either immersed in the Earth's umbral shadow (total and partial eclipses), or the penumbral shadow (penumbral eclipse). It is not a measure of brightness.

Please note, all times listed below are in UT.

PENUMBRAL LUNAR ECLIPSE - 26th May 2002

The first of the lunar eclipses is visible over the Pacific region and Australia. The penumbra magnitude at mid-eclipse is 0.71, just deep enough to subtly shade the Moon's far southern regions. Observers will need to look carefully, as anything less than 0.7 is generally considered too difficult to see. Binoculars will help in detecting the faint penumbral portion of the Earth's shadow.

Moon enters penumbra 26d 10h 12.7m UT
Middle of eclipse 26d 12h 03.3m
Moon leaves penumbra 26d 13h 53.8m

ANNULAR SOLAR ECLIPSE - 10/11th June 2002

With the exception of some small Indonesian islands, the path of annularity of this eclipse is solely over water. The track starts just north of the equator in the Celebes Sea, and then crosses the Pacific Ocean, ending just off the Mexican coast. From parts of the northern regions of Australia the partially eclipsed Sun will be seen at sunrise on the 11th. From Broome, Alice Springs and Darwin the partial phases begin before sunrise, from Cairns the partial eclipse is visible in its entirety.

DATE (0hr UT)	P°	B_o°	L_o°
Jan 5	+ 0.19	- 3.47	027.03
12	- 3.18	- 4.24	294.85
19	- 6.45	- 4.93	202.68
26	- 9.58	- 5.55	110.51
Feb 2	- 12.51	- 6.09	018.34
9	- 15.22	- 6.53	286.18
16	- 17.68	- 6.87	194.01
23	- 19.86	- 7.10	101.82
Mar 2	- 21.74	- 7.23	009.62
9	- 23.31	- 7.25	277.40
16	- 24.56	- 7.15	185.15
23	- 25.48	- 6.96	092.87
30	- 26.06	- 6.66	000.55
Apr 6	- 26.29	- 6.26	268.19
13	- 26.16	- 5.78	175.80
20	- 25.68	- 5.21	083.37
27	- 24.83	- 4.58	350.90
May 4	- 23.62	- 3.88	258.38
11	- 22.07	- 3.13	165.84
18	- 20.19	- 2.34	073.27
25	- 17.99	- 1.52	340.66
Jun 1	- 15.52	- 0.69	248.04
8	- 12.80	+ 0.16	155.39
15	- 9.89	+ 1.00	062.75
22	- 6.83	+ 1.83	330.09
29	- 3.69	+ 2.63	237.43
Jul 6	- 0.52	+ 3.40	144.78
13	+ 2.64	+ 4.12	052.14
20	+ 5.73	+ 4.78	319.51
27	+ 8.70	+ 5.38	226.90
Aug 3	+ 11.52	+ 5.91	134.32
10	+ 14.17	+ 6.36	041.76
17	+ 16.60	+ 6.73	309.22
24	+ 18.81	+ 7.00	216.71
31	+ 20.76	+ 7.17	124.23
Sep 7	+ 22.45	+ 7.25	031.77
14	+ 23.85	+ 7.22	299.34
21	+ 24.95	+ 7.09	206.93
28	+ 25.73	+ 6.86	114.54
Oct 5	+ 26.18	+ 6.53	022.17
12	+ 26.28	+ 6.10	289.83
19	+ 26.02	+ 5.58	197.49
26	+ 25.39	+ 4.98	105.16
Nov 2	+ 24.37	+ 4.30	012.86
9	+ 22.97	+ 3.55	280.56
16	+ 21.19	+ 2.75	188.28
23	+ 19.04	+ 1.91	096.00
30	+ 16.56	+ 1.03	003.74
Dec 7	+ 13.78	+ 0.14	271.50
14	+ 10.75	- 0.76	179.26
21	+ 7.53	- 1.64	087.04
28	+ 4.18	- 2.51	354.83

VARIATION OF L_o	
DAILY	
1	- 13.18
2	- 26.37
3	- 39.55
4	- 52.73
5	- 65.91
6	- 79.10
HOURLY	
1	- 0.55
2	- 1.10
3	- 1.65
4	- 2.20
5	- 2.75
6	- 3.30
7	- 3.84
8	- 4.39
9	- 4.94
10	- 5.49
11	- 6.04
12	- 6.59
13	- 7.14
14	- 7.69
15	- 8.24
16	- 8.79
17	- 9.34
18	- 9.89
19	- 10.43
20	- 10.98
21	- 11.53
22	- 12.08
23	- 12.63
24	- 13.18

SYNODIC ROTATION NUMBERS (UT)		
		d.dd
1985	Jan	7.06
1986	Feb	3.40
1987	Mar	2.73
1988	Mar	30.04
1989	Apr	26.31
1990	May	23.54
1991	Jun	19.74
1992	Jul	16.94
1993	Aug	13.16
1994	Sep	9.41
1995	Oct	6.68
1996	Nov	2.98
1997	Nov	30.29
1998	Dec	27.61

PENUMBRAL LUNAR ECLIPSE - 24th June 2002

Technically this eclipse is visible from Europe, Africa, Asia and Australia. In reality, with the penumbra magnitude at mid-eclipse only 0.23 (just under a quarter of the Moon's diameter), this is not deep enough for the Earth's shadow to be noticed against the lunar surface.

Moon enters penumbra 24d 20h 18.4m UT
Middle of eclipse 24d 21h 27.1m
Moon leaves penumbra 24d 22h 35.4m

PENUMBRAL LUNAR ECLIPSE - 19/20th November 2002

The last penumbral eclipse this year is not visible from Australia. From Europe, Africa, and the Americas, observers will see some darkening on the Moon's northern limb as it dips in the penumbral shadow with a magnitude of 0.89.

Moon enters penumbra 19d 23h 32.0m UT
Middle of eclipse 20d 01h 46.5m
Moon leaves penumbra 20d 04h 01.1m

TOTAL ECLIPSE of the SUN - 4th December 2002

The path of totality begins off the West Coast of Southern Africa, crosses Africa and the Indian Ocean, and finally reaches the Australian coast at Ceduna in South Australia. The total eclipse over South Australia is brief and low to the horizon, but nonetheless should generate much interest; it is our first total eclipse since 23rd October 1976. The partial phases of this year's event are visible across all of Australia, but from many locations, the pair sets before last contact. See also the article 'In the Shadow of the Moon' in part I, for the eclipse circumstances.

ADELAIDE

ACST

MOON RISE AND SET

AEST

BRISBANE

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	21 23	6 32	21 57	8 58	20 26	7 46	20 45	10 06
2	22 09	7 43	22 30	10 08	21 00	8 58	21 29	11 15
3	22 49	8 54	23 03	11 16	21 35	10 08	22 18	12 20
4	23 25	10 04	23 37	12 23	22 12	11 17	23 11	13 18
5	23 57	11 13	DNR	13 29	22 52	12 24	DNR	14 10
6	DNR	12 19	0 14	14 33	23 36	13 29	0 07	14 55
7	0 29	13 25	0 54	15 35	DNR	14 29	1 04	15 34
8	1 02	14 30	1 39	16 33	0 25	15 24	2 02	16 08
9	1 36	15 35	2 29	17 26	1 18	16 13	2 59	16 37
10	2 13	16 39	3 23	18 13	2 14	16 55	3 55	17 05
11	2 55	17 41	4 19	18 54	3 11	17 32	4 50	17 31
12	3 42	18 38	5 17	19 30	4 08	18 04	5 45	17 57
13	4 34	19 30	6 14	20 02	5 05	18 34	6 41	18 23
14	5 30	20 16	7 11	20 31	6 01	19 01	7 37	18 51
15	6 27	20 55	8 06	20 57	6 56	19 27	8 36	19 23
16	7 25	21 30	9 01	21 23	7 51	19 53	9 35	19 58
17	8 22	22 01	9 56	21 50	8 46	20 20	10 36	20 40
18	9 18	22 29	10 52	22 17	9 43	20 49	11 36	21 28
19	10 13	22 55	11 49	22 48	10 41	21 21	12 34	22 24
20	11 08	23 21	12 48	23 22	11 41	21 59	13 28	23 26
21	12 04	23 48	13 49	DNS	12 42	22 43	14 17	DNS
22	13 01	DNS	14 52	0 03	13 42	23 34	15 00	0 34
23	14 00	0 17	15 54	0 51	14 40	DNS	15 38	1 44
24	15 02	0 50	16 52	1 48	15 34	0 34	16 14	2 55
25	16 06	1 28	17 45	2 53	16 22	1 40	16 48	4 06
26	17 10	2 13	18 32	4 04	17 05	2 51	17 22	5 18
27	18 12	3 07	19 14	5 18	17 43	4 04	17 57	6 30
28	19 09	4 10	19 51	6 33	18 19	5 18	18 35	7 42
29	20 00	5 19			18 53	6 31	19 18	8 53
30	20 44	6 32			19 28	7 44	20 06	10 02
31	21 22	7 46			20 05	8 56		
	MAY		JUNE		JULY		AUGUST	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	20 59	11 06	22 39	12 08	23 19	11 39	DNR	11 24
2	21 55	12 02	23 37	12 41	DNR	12 05	0 51	11 52
3	22 54	12 52	DNR	13 10	0 14	12 30	1 50	12 25
4	23 53	13 33	0 34	13 37	1 09	12 56	2 50	13 03
5	DNR	14 09	1 29	14 03	2 05	13 24	3 52	13 49
6	0 51	14 40	2 24	14 29	3 04	13 54	4 53	14 42
7	1 47	15 08	3 20	14 55	4 04	14 30	5 52	15 44
8	2 43	15 35	4 17	15 24	5 06	15 12	6 45	16 53
9	3 38	16 00	5 17	15 57	6 09	16 01	7 32	18 04
10	4 33	16 26	6 18	16 35	7 09	16 59	8 13	19 17
11	5 30	16 54	7 21	17 20	8 05	18 03	8 50	20 28
12	6 28	17 24	8 22	18 12	8 55	19 12	9 24	21 38
13	7 28	17 58	9 21	19 11	9 39	20 23	9 56	22 48
14	8 29	18 38	10 13	20 16	10 17	21 33	10 29	23 56
15	9 31	19 25	11 00	21 24	10 51	22 41	11 03	DNS
16	10 30	20 19	11 40	22 33	11 23	23 49	11 41	1 04
17	11 26	21 19	12 16	23 41	11 55	DNS	12 24	2 12
18	12 16	22 24	12 49	DNS	12 27	0 56	13 12	3 16
19	12 59	23 32	13 20	0 49	13 02	2 04	14 06	4 16
20	13 38	DNS	13 52	1 56	13 42	3 12	15 04	5 09
21	14 13	0 41	14 26	3 04	14 26	4 18	16 04	6 56
22	14 46	1 50	15 03	4 13	15 17	5 22	17 04	8 36
23	15 19	2 59	15 45	5 22	16 13	6 21	18 03	9 10
24	15 52	4 08	16 32	6 30	17 12	7 14	19 00	7 41
25	16 28	5 19	17 26	7 34	18 13	7 58	19 56	8 08
26	17 08	6 30	18 24	8 31	19 13	8 37	20 51	8 34
27	17 53	7 40	19 25	9 21	20 12	9 10	21 47	8 59
28	18 44	8 47	20 26	10 03	21 09	9 39	22 42	9 25
29	19 40	9 49	21 25	10 39	22 04	10 06	23 39	9 52
30	20 40	10 43	22 23	11 11	22 59	10 32	DNR	10 23
31	21 40	11 29			23 55	10 57	0 38	10 58
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	1 38	11 39	2 22	12 11	3 09	14 28	2 44	15 40
2	2 39	12 28	3 12	13 17	3 42	15 39	3 18	16 52
3	3 37	13 25	3 57	14 27	4 15	16 50	3 54	18 05
4	4 32	14 29	4 37	15 39	4 48	18 04	4 35	19 18
5	5 21	15 40	5 13	16 52	5 24	19 18	5 24	20 28
6	6 05	16 52	5 47	18 05	6 03	20 33	6 19	21 31
7	6 44	18 06	6 21	19 18	6 48	21 44	7 19	22 25
8	7 20	19 19	6 56	20 32	7 40	22 50	8 23	23 11
9	7 53	20 31	7 33	21 45	8 37	23 47	9 27	23 48
10	8 27	21 42	8 14	22 56	9 38	DNS	10 28	DNS
11	9 01	22 53	9 01	DNS	10 40	0 35	11 27	0 20
12	9 39	DNS	9 53	0 03	11 41	1 16	12 24	0 48
13	10 21	0 03	10 50	1 03	12 40	1 50	13 20	1 14
14	11 09	1 10	11 50	1 54	13 38	2 19	14 15	1 39
15	12 01	2 12	12 50	2 38	14 33	2 46	15 11	2 04
16	12 58	3 07	13 50	3 15	15 28	3 11	16 08	2 30
17	13 57	3 56	14 48	3 47	16 24	3 36	17 06	2 59
18	14 57	4 37	15 44	4 16	17 20	4 01	18 06	3 32
19	15 56	5 13	16 40	4 42	18 17	4 29	19 07	4 11
20	16 54	5 44	17 35	5 07	19 17	4 59	20 06	4 56
21	17 50	6 11	18 30	5 32	20 17	5 33	21 01	5 48
22	18 45	6 37	19 27	5 58	21 16	6 14	21 50	6 48
23	19 40	7 02	20 24	6 26	22 13	7 01	22 33	7 52
24	20 36	7 28	21 23	6 57	23 05	7 55	23 10	8 58
25	21 32	7 54	22 23	7 33	23 51	8 55	23 44	10 06
26	22 30	8 23	23 21	8 15	DNR	9 59	DNR	11 12
27	23 29	8 56	DNR	9 04	0 32	11 06	0 15	12 19
28	DNR	9 34	0 16	10 00	1 08	12 13	0 46	13 26
29	0 29	10 19	1 07	11 02	1 42	13 21	1 17	14 35
30	1 27	11 11	1 52	12 09	2 13	14 30	1 50	15 45
31			2 32	13 17			2 28	16 57

Note: DNR means Moon does not rise on that day, DNS means Moon does not set. See explanation page 73.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h mm	h mm	h mm	h mm	h mm	h mm	h mm	h mm
1	20 36	6 21	21 25	8 33	19 57	7 19	20 30	9 23
2	21 26	7 29	22 03	9 39	20 35	8 26	21 17	10 28
3	22 10	8 36	22 40	10 42	21 14	9 31	22 08	11 30
4	22 50	9 42	23 18	11 45	21 55	10 36	23 01	12 28
5	23 27	10 46	23 58	12 46	22 39	11 39	23 56	13 21
6	DNR	11 48	DNR	13 47	23 25	12 41	DNR	14 08
7	0 03	12 50	0 42	14 47	DNR	13 39	0 52	14 49
8	0 40	13 51	1 29	15 44	0 15	14 34	1 47	15 26
9	1 18	14 52	2 19	16 37	1 08	15 24	2 40	16 00
10	1 59	15 52	3 13	17 25	2 03	16 09	3 33	16 31
11	2 43	16 52	4 07	18 09	2 57	16 48	4 24	17 00
12	3 32	17 49	5 02	18 48	3 52	17 24	5 16	17 30
13	4 24	18 41	5 57	19 23	4 45	17 57	6 07	18 00
14	5 19	19 29	6 50	19 55	5 37	18 28	7 00	18 32
15	6 14	20 11	7 42	20 26	6 29	18 58	7 54	19 07
16	7 10	20 49	8 33	20 55	7 20	19 27	8 50	19 45
17	8 04	21 23	9 24	21 25	8 11	19 58	9 48	20 29
18	8 56	21 54	10 16	21 56	9 04	20 30	10 46	21 19
19	9 48	22 24	11 09	22 30	9 59	21 06	11 44	22 15
20	10 39	22 54	12 05	23 08	10 55	21 46	12 39	23 16
21	11 30	23 25	13 03	23 51	11 53	22 32	13 30	DNS
22	12 24	23 58	14 03	DNS	12 52	23 25	14 16	0 20
23	13 19	DNS	15 03	0 41	13 50	DNS	14 59	1 26
24	14 17	0 34	16 03	1 38	14 45	0 24	15 39	2 32
25	15 18	1 15	16 58	2 42	15 36	1 28	16 18	3 39
26	16 20	2 02	17 49	3 50	16 23	2 36	16 57	4 45
27	17 22	2 57	18 35	5 00	17 06	3 44	17 36	5 52
28	18 21	3 59	19 17	6 10	17 47	4 53	18 19	7 00
29	19 15	5 07			18 26	6 01	19 05	8 07
30	20 03	6 16			19 06	7 09	19 56	9 13
31	20 46	7 26			19 47	8 16		
	MAY		JUNE		JULY		AUGUST	
1	20 49	10 15	22 23	11 23	22 54	11 04	DNR	11 02
2	21 46	11 12	23 18	12 00	23 45	11 34	0 12	11 35
3	22 43	12 03	DNR	12 33	DNR	12 03	1 07	12 11
4	23 39	12 47	0 11	13 04	0 36	12 32	2 04	12 52
5	DNR	13 26	1 02	13 33	1 29	13 04	3 03	13 39
6	0 33	14 01	1 54	14 03	2 23	13 38	4 03	14 33
7	1 27	14 33	2 45	14 33	3 19	14 17	5 01	15 34
8	2 18	15 03	3 39	15 06	4 18	15 01	5 57	16 40
9	3 10	15 32	4 34	15 42	5 19	15 52	6 47	17 48
10	4 01	16 02	5 32	16 23	6 18	16 50	7 32	18 56
11	4 54	16 33	6 32	17 10	7 16	17 52	8 14	20 03
12	5 48	17 07	7 32	18 03	8 08	18 58	8 52	21 08
13	6 44	17 45	8 30	19 02	8 55	20 05	9 29	22 13
14	7 42	18 27	9 24	20 05	9 38	21 10	10 06	23 17
15	8 41	19 15	10 14	21 09	10 17	22 15	10 45	DNS
16	9 40	20 10	10 58	22 14	10 53	23 18	11 27	0 21
17	10 36	21 09	11 38	23 18	11 29	DNS	12 13	1 24
18	11 28	22 12	12 16	DNS	12 06	0 20	13 03	2 26
19	12 15	23 16	12 52	0 21	12 45	1 23	13 57	3 25
20	12 58	DNS	13 28	1 24	13 28	2 27	14 54	4 20
21	13 37	0 21	14 06	2 27	14 16	3 30	15 51	5 08
22	14 15	1 25	14 47	3 31	15 08	4 32	16 49	5 51
23	14 52	2 29	15 32	4 36	16 04	5 31	17 44	6 29
24	15 30	3 34	16 22	5 41	17 02	6 24	18 38	7 03
25	16 10	4 39	17 17	6 43	18 00	7 12	19 30	7 34
26	16 54	5 46	18 15	7 41	18 57	7 53	20 21	8 04
27	17 42	6 53	19 13	8 32	19 52	8 30	21 13	8 33
28	18 35	7 57	20 11	9 17	20 45	9 03	22 04	9 02
29	19 31	8 58	21 07	9 57	21 37	9 34	22 58	9 33
30	20 29	9 53	22 01	10 32	22 28	10 03	23 53	10 07
31	21 27	10 41			23 19	10 32	DNR	10 45
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	0 50	11 29	1 31	12 01	2 30	14 05	2 18	15 04
2	1 48	12 19	2 23	13 05	3 08	15 11	2 56	16 11
3	2 46	13 16	3 11	14 11	3 46	16 18	3 37	17 20
4	3 42	14 19	3 56	15 19	4 24	17 26	4 22	18 29
5	4 34	15 26	4 37	16 26	5 05	18 35	5 13	19 37
6	5 22	16 34	5 16	17 34	5 48	19 45	6 10	20 40
7	6 06	17 43	5 55	18 43	6 37	20 54	7 11	21 36
8	6 46	18 51	6 34	19 51	7 31	21 58	8 12	22 24
9	7 25	19 58	7 16	21 00	8 28	22 56	9 13	23 05
10	8 03	21 04	8 01	22 08	9 28	23 47	10 11	23 41
11	8 42	22 11	8 51	23 12	10 28	DNS	11 07	DNS
12	9 24	23 16	9 45	DNS	11 26	0 30	12 00	0 13
13	10 09	DNS	10 41	0 12	12 22	1 08	12 51	0 43
14	10 59	0 20	11 40	1 05	13 15	1 42	13 42	1 11
15	11 52	1 21	12 37	1 51	14 07	2 12	14 34	1 40
16	12 48	2 17	13 34	2 31	14 58	2 41	15 27	2 10
17	13 46	3 07	14 28	3 07	15 50	3 10	16 22	2 43
18	14 43	3 51	15 21	3 39	16 42	3 39	17 19	3 19
19	15 38	4 30	16 12	4 09	17 35	4 10	18 17	4 00
20	16 32	5 05	17 03	4 38	18 31	4 43	19 14	4 47
21	17 25	5 36	17 55	5 07	19 28	5 21	20 10	5 40
22	18 16	6 06	18 47	5 37	20 25	6 04	21 01	6 38
23	19 08	6 35	19 41	6 08	21 21	6 53	21 47	7 40
24	19 59	7 04	20 37	6 43	22 14	7 47	22 29	8 43
25	20 52	7 34	21 33	7 22	23 03	8 45	23 07	9 46
26	21 46	8 07	22 30	8 06	23 48	9 47	23 43	10 48
27	22 42	8 43	23 25	8 56	DNR	10 49	DNR	11 50
28	23 39	9 24	DNR	9 52	0 28	11 52	0 18	12 53
29	DNR	10 10	0 17	10 52	1 06	12 56	0 53	13 57
30	0 36	11 03	1 05	11 55	1 42	13 59	1 31	15 02
31			1 49	12 59			2 13	16 09

CANBERRA

AEST

MOON RISE AND SET

ACST

DARWIN

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h mm	h mm	h mm	h mm	h mm	h mm	h mm	h mm
1	21 11	6 18	21 44	8 44	20 13	7 32	20 31	9 53
2	21 57	7 28	22 17	9 54	20 47	8 44	21 15	11 02
3	22 37	8 39	22 50	11 02	21 21	9 54	22 03	12 07
4	23 12	9 50	23 24	12 09	21 58	11 04	22 56	13 06
5	23 45	10 58	DNR	13 15	22 38	12 11	23 52	13 58
6	DNR	12 05	0 00	14 20	23 22	13 16	DNR	14 43
7	0 16	13 11	0 40	15 22	DNR	14 16	0 50	15 21
8	0 48	14 17	1 25	16 20	0 11	15 11	1 48	15 55
9	1 22	15 22	2 15	17 13	1 03	16 00	2 45	16 25
10	2 00	16 26	3 08	18 01	1 59	16 43	3 41	16 52
11	2 41	17 28	4 05	18 42	2 57	17 20	4 36	17 18
12	3 28	18 25	5 03	19 18	3 54	17 52	5 32	17 44
13	4 20	19 17	6 00	19 49	4 51	18 21	6 27	18 10
14	5 15	20 03	6 57	20 18	5 47	18 48	7 24	18 38
15	6 13	20 43	7 52	20 45	6 42	19 14	8 22	19 09
16	7 11	21 17	8 47	21 11	7 37	19 40	9 22	19 45
17	8 08	21 48	9 43	21 37	8 33	20 07	10 23	20 26
18	9 04	22 16	10 38	22 04	9 30	20 35	11 23	21 14
19	10 00	22 42	11 36	22 34	10 28	21 08	12 21	22 09
20	10 55	23 08	12 35	23 09	11 28	21 45	13 15	23 12
21	11 50	23 35	13 36	23 49	12 29	22 28	14 04	DNS
22	12 47	DNS	14 39	DNS	13 29	23 20	14 47	0 19
23	13 47	0 04	15 41	0 37	14 27	DNS	15 26	1 29
24	14 48	0 37	16 39	1 33	15 21	0 19	16 01	2 40
25	15 52	1 14	17 33	2 38	16 09	1 25	16 35	3 52
26	16 57	1 59	18 20	3 49	16 52	2 36	17 08	5 04
27	17 59	2 53	19 01	5 04	17 30	3 50	17 43	6 16
28	18 57	3 55	19 38	6 18	18 06	5 04	18 21	7 28
29	19 47	5 04			18 40	6 17	19 04	8 40
30	20 31	6 18			19 15	7 30	19 51	9 49
31	21 09	7 31			19 51	8 42		
MAY		JUNE		JULY		AUGUST		
1	20 44	10 53	22 25	11 55	23 05	11 26	DNR	11 10
2	21 41	11 50	23 23	12 29	DNR	11 52	0 38	11 39
3	22 39	12 39	DNR	12 58	0 00	12 17	1 37	12 12
4	23 38	13 21	0 20	13 25	0 56	12 43	2 37	12 49
5	DNR	13 57	1 15	13 50	1 52	13 11	3 39	13 34
6	0 36	14 28	2 11	14 16	2 50	13 41	4 41	14 28
7	1 33	14 56	3 07	14 42	3 51	14 16	5 39	15 30
8	2 29	15 22	4 04	15 11	4 53	14 58	6 32	16 38
9	3 24	15 48	5 04	15 43	5 56	15 47	7 20	17 50
10	4 20	16 13	6 05	16 21	6 56	16 44	8 01	19 02
11	5 17	16 41	7 08	17 05	7 53	17 49	8 37	20 14
12	6 15	17 11	8 09	17 57	8 43	18 57	9 11	21 24
13	7 15	17 45	9 08	18 57	9 26	20 08	9 43	22 34
14	8 16	18 24	10 01	20 02	10 04	21 18	10 15	23 43
15	9 18	19 11	10 47	21 10	10 38	22 27	10 50	DNS
16	10 17	20 04	11 27	22 19	11 10	23 35	11 27	0 51
17	11 13	21 04	12 03	23 27	11 42	DNS	12 10	1 58
18	12 03	22 10	12 36	DNS	12 14	0 43	12 58	3 03
19	12 47	23 18	13 07	0 35	12 49	1 50	13 51	4 03
20	13 26	DNS	13 39	1 43	13 28	2 58	14 49	4 57
21	14 01	0 27	14 12	2 51	14 12	4 05	15 49	5 44
22	14 34	1 36	14 49	4 00	15 02	5 09	16 49	6 24
23	15 06	2 45	15 31	5 09	15 58	6 09	17 49	6 58
24	15 39	3 55	16 18	6 17	16 58	7 01	18 46	7 28
25	16 14	5 05	17 12	7 21	17 59	7 46	19 43	7 56
26	16 54	6 16	18 10	8 18	18 59	8 24	20 38	8 21
27	17 39	7 27	19 10	9 08	19 58	8 58	21 33	8 46
28	18 30	8 34	20 11	9 51	20 55	9 27	22 29	9 12
29	19 26	9 36	21 11	10 27	21 51	9 53	23 26	9 39
30	20 25	10 30	22 09	10 58	22 46	10 19	DNR	10 09
31	21 25	11 16			23 41	10 44	0 25	10 44
SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		
1	1 25	11 25	2 09	11 56	2 56	14 13	2 31	15 26
2	2 26	12 13	2 59	13 02	3 30	15 24	3 04	16 38
3	3 24	13 10	3 44	14 12	4 02	16 36	3 40	17 52
4	4 19	14 15	4 24	15 24	4 35	17 50	4 21	19 05
5	5 09	15 25	5 00	16 37	5 10	19 05	5 09	20 15
6	5 53	16 38	5 34	17 51	5 50	20 19	6 04	21 18
7	6 31	17 51	6 08	19 04	6 34	21 31	7 05	22 13
8	7 07	19 04	6 42	20 18	7 25	22 37	8 08	22 58
9	7 40	20 17	7 19	21 32	8 22	23 34	9 12	23 36
10	8 13	21 28	8 00	22 43	9 23	DNS	10 14	DNS
11	8 48	22 40	8 47	23 50	10 25	0 23	11 13	0 08
12	9 25	23 50	9 39	DNS	11 27	1 03	12 11	0 36
13	10 07	DNS	10 36	0 50	12 26	1 37	13 06	1 02
14	10 54	0 57	11 35	1 42	13 24	2 07	14 02	1 26
15	11 47	1 59	12 36	2 26	14 20	2 34	14 57	1 51
16	12 43	2 55	13 35	3 03	15 15	2 59	15 54	2 17
17	13 43	3 43	14 34	3 35	16 10	3 23	16 53	2 46
18	14 42	4 25	15 30	4 03	17 06	3 48	17 53	3 18
19	15 42	5 00	16 26	4 29	18 04	4 15	18 54	3 57
20	16 40	5 31	17 21	4 54	19 03	4 45	19 53	4 41
21	17 36	5 59	18 17	5 19	20 04	5 20	20 48	5 34
22	18 32	6 25	19 14	5 45	21 03	6 00	21 37	6 33
23	19 27	6 50	20 11	6 13	22 00	6 47	22 20	7 37
24	20 23	7 15	21 10	6 44	22 52	7 40	22 58	8 44
25	21 19	7 41	22 10	7 20	23 39	8 40	23 31	9 51
26	22 17	8 10	23 08	8 01	DNR	9 45	DNR	10 58
27	23 16	8 43	DNR	8 50	0 20	10 51	0 02	12 05
28	DNR	9 20	0 03	9 46	0 56	11 59	0 33	13 13
29	0 16	10 05	0 54	10 48	1 29	13 07	1 04	14 21
30	1 14	10 57	1 39	11 54	2 00	14 16	1 37	15 32
31			2 20	13 03			2 14	16 43

Note: DNR means Moon does not rise on that day, DNS means Moon does not set. See explanation page 73.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h mm	h mm	h mm	h mm	h mm	h mm	h mm	h mm
1	21 10	7 55	22 22	9 45	20 58	8 26	21 57	10 03
2	22 04	8 58	23 07	10 42	21 44	9 25	22 49	11 02
3	22 55	9 59	23 51	11 38	22 31	10 22	23 43	12 01
4	23 42	10 58	DNR	12 33	23 18	11 20	DNR	12 57
5	DNR	11 55	0 36	13 28	DNR	12 17	0 37	13 50
6	0 26	12 49	1 23	14 23	0 07	13 14	1 30	14 39
7	1 10	13 43	2 11	15 19	0 58	14 09	2 22	15 24
8	1 53	14 37	3 02	16 13	1 50	15 03	3 13	16 06
9	2 38	15 32	3 54	17 06	2 43	15 54	4 01	16 45
10	3 25	16 27	4 47	17 56	3 35	16 41	4 47	17 22
11	4 14	17 23	5 39	18 43	4 26	17 25	5 32	17 58
12	5 06	18 18	6 30	19 26	5 16	18 06	6 17	18 34
13	5 59	19 11	7 19	20 07	6 03	18 45	7 02	19 10
14	6 52	20 00	8 06	20 45	6 49	19 21	7 49	19 49
15	7 45	20 46	8 52	21 21	7 34	19 57	8 37	20 29
16	8 35	21 29	9 37	21 57	8 19	20 33	9 28	21 14
17	9 24	22 08	10 22	22 33	9 05	21 10	10 21	22 02
18	10 10	22 46	11 07	23 10	9 51	21 49	11 16	22 55
19	10 56	23 22	11 55	23 50	10 40	22 30	12 12	23 51
20	11 41	23 58	12 45	DNS	11 31	23 16	13 08	DNS
21	12 26	DNS	13 38	0 34	12 25	DNS	14 02	0 50
22	13 13	0 35	14 34	1 22	13 21	0 06	14 55	1 49
23	14 02	1 14	15 33	2 15	14 18	1 01	15 44	2 49
24	14 55	1 56	16 32	3 14	15 16	1 59	16 32	3 48
25	15 51	2 43	17 31	4 16	16 11	3 00	17 18	4 47
26	16 51	3 35	18 27	5 20	17 04	4 03	18 05	5 45
27	17 52	4 33	19 20	6 24	17 55	5 04	18 53	6 44
28	18 52	5 35	20 10	7 26	18 43	6 05	19 43	7 44
29	19 50	6 39			19 31	7 05	20 35	8 44
30	20 44	7 43			20 18	8 04	21 30	9 45
31	21 35	8 45			21 07	9 03		
	MAY		JUNE		JULY		AUGUST	
1	22 25	10 44	23 49	11 59	DNR	11 54	0 12	12 15
2	23 21	11 41	DNR	12 41	0 03	12 30	0 58	12 54
3	DNR	12 33	0 37	13 20	0 48	13 06	1 47	13 36
4	0 15	13 21	1 24	13 57	1 33	13 42	2 39	14 22
5	1 07	14 04	2 09	14 33	2 18	14 19	3 34	15 14
6	1 56	14 44	2 54	15 08	3 06	15 00	4 31	16 10
7	2 43	15 22	3 39	15 45	3 57	15 44	5 30	17 10
8	3 29	15 58	4 26	16 24	4 51	16 34	6 27	18 12
9	4 14	16 34	5 16	17 06	5 48	17 28	7 23	19 15
10	4 59	17 10	6 08	17 53	6 47	18 26	8 15	20 15
11	5 45	17 48	7 03	18 44	7 45	19 27	9 03	21 14
12	6 33	18 28	8 00	19 39	8 41	20 28	9 49	22 11
13	7 23	19 11	8 58	20 38	9 34	21 28	10 34	23 07
14	8 16	19 59	9 55	21 38	10 23	22 26	11 19	DNS
15	9 11	20 51	10 48	22 37	11 09	23 22	12 05	0 04
16	10 08	21 46	11 38	23 35	11 53	DNS	12 54	1 01
17	11 04	22 44	12 25	DNS	12 37	0 17	13 45	1 58
18	11 59	23 43	13 10	0 31	13 21	1 12	14 38	2 56
19	12 51	DNS	13 54	1 26	14 07	2 08	15 33	3 53
20	13 40	0 42	14 38	2 21	14 57	3 05	16 29	4 48
21	14 26	1 39	15 23	3 17	15 49	4 03	17 23	5 39
22	15 12	2 36	16 11	4 14	16 43	5 02	18 15	6 26
23	15 56	3 32	17 02	5 13	17 40	5 59	19 04	7 09
24	16 42	4 29	17 57	6 12	18 35	6 53	19 52	7 49
25	17 30	5 27	18 53	7 12	19 29	7 44	20 37	8 26
26	18 21	6 26	19 50	8 09	20 21	8 30	21 22	9 02
27	19 14	7 27	20 46	9 03	21 10	9 12	22 07	9 38
28	20 10	8 27	21 39	9 51	21 57	9 51	22 52	10 13
29	21 07	9 26	22 29	10 36	22 42	10 28	23 40	10 51
30	22 03	10 22	23 17	11 16	23 27	11 03	DNR	11 31
31	22 57	11 13			DNR	11 39	0 29	12 14
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	1 22	13 02	1 59	13 37	3 15	15 20	3 24	15 58
2	2 17	13 55	2 54	14 37	4 02	16 18	4 10	16 57
3	3 14	14 53	3 47	15 37	4 47	17 16	4 59	17 58
4	4 11	15 53	4 38	16 38	5 34	18 15	5 51	19 02
5	5 07	16 55	5 26	17 37	6 23	19 17	6 48	20 05
6	6 01	17 57	6 14	18 37	7 14	20 20	7 48	21 07
7	6 51	18 58	7 01	19 36	8 09	21 24	8 48	22 04
8	7 40	19 57	7 48	20 37	9 07	22 26	9 47	22 56
9	8 26	20 55	8 38	21 38	10 06	23 24	10 42	23 42
10	9 13	21 54	9 30	22 40	11 04	DNS	11 35	DNS
11	10 00	22 53	10 25	23 41	12 00	0 17	12 23	0 24
12	10 49	23 52	11 22	DNS	12 53	1 05	13 10	1 02
13	11 40	DNS	12 18	0 39	13 42	1 48	13 55	1 38
14	12 34	0 51	13 14	1 33	14 29	2 27	14 39	2 14
15	13 29	1 49	14 07	2 23	15 15	3 04	15 24	2 49
16	14 24	2 45	14 58	3 08	15 59	3 39	16 11	3 25
17	15 19	3 37	15 46	3 49	16 44	4 14	17 00	4 04
18	16 11	4 24	16 32	4 27	17 30	4 50	17 52	4 46
19	17 01	5 08	17 17	5 04	18 17	5 27	18 46	5 33
20	17 48	5 49	18 02	5 39	19 07	6 07	19 41	6 23
21	18 34	6 26	18 47	6 14	19 59	6 51	20 37	7 18
22	19 19	7 02	19 33	6 50	20 53	7 38	21 31	8 15
23	20 04	7 38	20 21	7 28	21 48	8 30	22 22	9 13
24	20 49	8 13	21 11	8 09	22 42	9 24	23 09	10 10
25	21 36	8 50	22 03	8 53	23 34	10 21	23 54	11 06
26	22 24	9 29	22 57	9 41	DNR	11 18	DNR	12 01
27	23 15	10 10	23 52	10 33	0 24	12 14	0 38	12 55
28	DNR	10 56	DNR	11 29	1 11	13 10	1 21	13 50
29	0 08	11 46	0 46	12 26	1 56	14 06	2 04	14 45
30	1 03	12 40	1 38	13 24	2 40	15 01	2 50	15 44
31			2 28	14 22			3 39	16 44

HOBART

AEST

MOON RISE AND SET

AEST

MELBOURNE

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	21 40	6 02	21 56	8 45	20 22	7 36	20 20	10 18
2	22 22	7 15	22 23	10 01	20 50	8 54	21 00	11 31
3	22 57	8 32	22 51	11 15	21 19	10 11	21 46	12 39
4	23 27	9 48	23 19	12 28	21 50	11 25	22 38	13 39
5	23 54	11 02	23 51	13 39	22 26	12 38	23 36	14 31
6	DNR	12 14	DNR	14 48	23 06	13 46	DNR	15 13
7	0 20	13 26	0 27	15 53	23 53	14 49	0 36	15 49
8	0 47	14 36	1 09	16 53	DNR	15 45	1 37	16 18
9	1 17	15 46	1 57	17 46	0 46	16 32	2 39	16 44
10	1 49	16 55	2 52	18 32	1 44	17 12	3 39	17 07
11	2 27	17 59	3 50	19 10	2 44	17 45	4 40	17 28
12	3 12	18 58	4 51	19 42	3 45	18 14	5 40	17 49
13	4 02	19 50	5 53	20 10	4 46	18 39	6 40	18 11
14	4 59	20 34	6 54	20 34	5 47	19 01	7 42	18 35
15	5 59	21 10	7 54	20 56	6 47	19 23	8 45	19 01
16	7 01	21 41	8 54	21 18	7 47	19 44	9 49	19 32
17	8 02	22 07	9 53	21 39	8 47	20 06	10 54	20 10
18	9 03	22 31	10 54	22 02	9 48	20 31	11 57	20 56
19	10 03	22 53	11 56	22 28	10 51	20 58	12 56	21 51
20	11 03	23 14	13 00	22 58	11 56	21 32	13 49	22 55
21	12 03	23 36	14 05	23 35	13 00	22 12	14 34	DNS
22	13 05	DNS	15 11	DNS	14 03	23 02	15 13	0 06
23	14 09	0 01	16 14	0 20	15 01	DNS	15 46	1 21
24	15 15	0 29	17 12	1 15	15 53	0 01	16 16	2 38
25	16 23	1 02	18 02	2 22	16 37	1 10	16 43	3 56
26	17 30	1 44	18 45	3 36	17 15	2 26	17 11	5 14
27	18 33	2 35	19 21	4 56	17 48	3 45	17 41	6 32
28	19 28	3 38	19 53	6 17	18 18	5 05	18 13	7 50
29	20 15	4 50			18 46	6 24	18 51	9 07
30	20 53	6 08			19 15	7 43	19 35	10 20
31	21 27	7 27			19 46	9 01		
	MAY		JUNE		JULY		AUGUST	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	20 26	11 27	22 15	12 22	23 07	11 41	DNR	11 09
2	21 23	12 24	23 18	12 51	DNR	12 03	0 58	11 33
3	22 24	13 11	DNR	13 16	0 08	12 24	2 01	12 01
4	23 26	13 50	0 19	13 38	1 08	12 45	3 06	12 35
5	DNR	14 22	1 20	13 59	2 09	13 08	4 12	13 17
6	0 29	14 49	2 20	14 20	3 12	13 34	5 15	14 09
7	1 30	15 12	3 20	14 42	4 17	14 04	6 13	15 12
8	2 31	15 34	4 23	15 06	5 23	14 42	7 04	16 23
9	3 31	15 55	5 27	15 34	6 29	15 29	7 47	17 40
10	4 31	16 16	6 33	16 08	7 31	16 26	8 23	18 58
11	5 32	16 39	7 40	16 49	8 26	17 32	8 54	20 16
12	6 35	17 04	8 44	17 39	9 13	18 45	9 22	21 32
13	7 40	17 34	9 42	18 39	9 52	20 00	9 48	22 48
14	8 46	18 09	10 33	19 46	10 24	21 16	10 15	DNS
15	9 51	18 53	11 15	20 59	10 53	22 31	10 44	0 02
16	10 52	19 46	11 51	22 13	11 19	23 45	11 17	1 16
17	11 47	20 47	12 22	23 27	11 45	DNS	11 55	2 28
18	12 34	21 56	12 49	DNS	12 12	0 58	12 40	3 36
19	13 14	23 08	13 15	0 40	12 42	2 11	13 33	4 38
20	13 48	DNS	13 41	1 54	13 16	3 25	14 32	5 31
21	14 17	0 22	14 09	3 08	13 56	4 36	15 35	6 15
22	14 45	1 37	14 40	4 22	14 45	5 43	16 39	6 51
23	15 11	2 52	15 17	5 37	15 40	6 43	17 43	7 21
24	15 39	4 08	16 01	6 49	16 41	7 34	18 45	7 47
25	16 09	5 25	16 53	7 55	17 46	8 16	19 46	8 10
26	16 43	6 41	17 52	8 52	18 50	8 50	20 46	8 31
27	17 24	7 57	18 55	9 40	19 54	9 19	21 46	8 51
28	18 12	9 07	20 00	10 19	20 56	9 44	22 47	9 12
29	19 07	10 10	21 04	10 51	21 56	10 06	23 49	9 35
30	20 08	11 03	22 07	11 18	22 56	10 27	DNR	10 01
31	21 12	11 47			23 56	10 48	0 52	10 31
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	1 56	11 09	2 43	11 38	3 15	14 12	2 36	15 40
2	3 00	11 55	3 31	12 47	3 43	15 29	3 03	16 58
3	3 59	12 51	4 12	14 02	4 10	16 48	3 33	18 18
4	4 53	13 58	4 47	15 20	4 37	18 08	4 09	19 37
5	5 39	15 12	5 17	16 39	5 06	19 28	4 53	20 50
6	6 18	16 31	5 45	17 59	5 40	20 48	5 45	21 54
7	6 51	17 50	6 12	19 19	6 20	22 04	6 46	22 46
8	7 20	19 10	6 41	20 39	7 07	23 12	7 52	23 28
9	7 48	20 28	7 12	21 58	8 03	DNS	8 59	DNS
10	8 15	21 46	7 48	23 14	9 05	0 09	10 06	0 01
11	8 44	23 03	8 30	DNS	10 10	0 55	11 10	0 29
12	9 16	DNS	9 20	0 24	11 16	1 31	12 12	0 52
13	9 53	0 18	10 17	1 25	12 20	2 01	13 13	1 13
14	10 37	1 29	11 18	2 15	13 22	2 26	14 13	1 33
15	11 28	2 34	12 22	2 56	14 23	2 48	15 14	1 53
16	12 25	3 29	13 26	3 29	15 23	3 08	16 16	2 14
17	13 27	4 16	14 29	3 57	16 24	3 28	17 19	2 39
18	14 31	4 54	15 31	4 20	17 25	3 49	18 24	3 07
19	15 34	5 25	16 31	4 42	18 27	4 11	19 28	3 41
20	16 37	5 51	17 32	5 02	19 31	4 36	20 28	4 23
21	17 38	6 15	18 32	5 22	20 35	5 06	21 23	5 14
22	18 39	6 36	19 34	5 43	21 38	5 43	22 09	6 14
23	19 39	6 56	20 36	6 07	22 35	6 27	22 48	7 22
24	20 39	7 17	21 40	6 33	23 26	7 21	23 21	8 33
25	21 41	7 38	22 43	7 05	DNR	8 23	23 49	9 46
26	22 43	8 03	23 43	7 44	0 10	9 30	DNR	10 59
27	23 46	8 31	DNR	8 31	0 46	10 42	0 15	12 11
28	DNR	9 05	0 39	9 27	1 17	11 55	0 39	13 25
29	0 49	9 46	1 28	10 31	1 45	13 09	1 05	14 40
30	1 49	10 37	2 09	11 41	2 11	14 24	1 32	15 56
31			2 45	12 56			2 04	17 13

Note: DNR means Moon does not rise on that day, DNS means Moon does not set. See explanation page 73.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	21 35	6 27	22 02	8 59	20 30	7 48	20 42	10 16
2	22 19	7 39	22 34	10 11	21 02	9 02	21 25	11 26
3	22 57	8 52	23 04	11 21	21 35	10 14	22 13	12 32
4	23 31	10 04	23 37	12 30	22 10	11 25	23 05	13 31
5	DNR	11 14	DNR	13 37	22 49	12 34	DNR	14 23
6	0 02	12 23	0 12	14 43	23 32	13 40	0 02	15 07
7	0 32	13 31	0 51	15 46	DNR	14 41	1 00	15 45
8	1 02	14 38	1 35	16 45	0 20	15 36	1 59	16 17
9	1 35	15 44	2 24	17 38	1 13	16 25	2 57	16 45
10	2 11	16 50	3 18	18 25	2 09	17 06	3 55	17 11
11	2 51	17 52	4 15	19 05	3 07	17 42	4 52	17 36
12	3 37	18 50	5 14	19 40	4 06	18 13	5 49	18 00
13	4 29	19 42	6 12	20 10	5 04	18 41	6 46	18 25
14	5 25	20 27	7 10	20 37	6 01	19 07	7 44	18 51
15	6 23	21 06	8 08	21 03	6 58	19 31	8 44	19 21
16	7 22	21 39	9 04	21 27	7 55	19 56	9 45	19 55
17	8 21	22 08	10 01	21 52	8 52	20 21	10 47	20 35
18	9 19	22 35	10 58	22 18	9 50	20 48	11 49	21 23
19	10 15	23 00	11 57	22 47	10 50	21 19	12 47	22 18
20	11 12	23 25	12 58	23 20	11 51	21 55	13 40	23 21
21	12 09	23 50	14 00	23 59	12 53	22 38	14 28	DNS
22	13 07	DNS	15 04	DNS	13 54	23 29	15 10	0 30
23	14 08	0 17	16 06	0 46	14 52	DNS	15 47	1 41
24	15 12	0 48	17 04	1 42	15 45	0 28	16 20	2 54
25	16 17	1 25	17 57	2 48	16 32	1 35	16 52	4 08
26	17 22	2 09	18 42	4 00	17 14	2 48	17 24	5 22
27	18 25	3 02	19 22	5 16	17 50	4 03	17 57	6 36
28	19 21	4 04	19 57	6 33	18 24	5 19	18 33	7 50
29	20 10	5 15			18 57	6 34	19 14	9 03
30	20 53	6 29			19 29	7 49	20 01	10 13
31	21 29	7 45			20 04	9 03		
	MAY		JUNE		JULY		AUGUST	
1	20 53	11 18	22 37	12 18	23 20	11 45	0 01	11 24
2	21 50	12 15	23 36	12 50	DNR	12 10	0 59	11 52
3	22 49	13 04	DNR	13 18	0 17	12 34	1 59	12 23
4	23 49	13 45	0 34	13 43	1 14	12 58	3 01	12 59
5	DNR	14 19	1 31	14 08	2 12	13 24	4 04	13 44
6	0 49	14 49	2 28	14 31	3 12	13 53	5 06	14 37
7	1 47	15 15	3 26	14 56	4 14	14 27	6 05	15 39
8	2 44	15 40	4 25	15 24	5 17	15 07	6 57	16 48
9	3 41	16 04	5 26	15 55	6 21	15 56	7 43	18 01
10	4 38	16 29	6 29	16 31	7 22	16 53	8 22	19 16
11	5 36	16 54	7 32	17 15	8 18	17 58	8 57	20 29
12	6 36	17 23	8 35	18 06	9 07	19 08	9 29	21 42
13	7 37	17 56	9 33	19 06	9 49	20 20	9 59	22 53
14	8 40	18 34	10 25	20 12	10 25	21 32	10 30	DNS
15	9 43	19 20	11 10	21 21	10 57	22 43	11 02	0 04
16	10 43	20 13	11 49	22 32	11 28	23 53	11 39	1 14
17	11 38	21 14	12 23	23 42	11 57	DNS	12 20	2 23
18	12 27	22 20	12 54	DNS	12 28	1 02	13 07	3 28
19	13 10	23 29	13 24	0 51	13 01	2 12	14 00	4 29
20	13 47	DNS	13 54	2 01	13 39	3 21	14 58	5 22
21	14 20	0 40	14 26	3 11	14 22	4 30	15 59	6 08
22	14 52	1 51	15 01	4 22	15 11	5 35	17 01	6 47
23	15 22	3 02	15 41	5 32	16 07	6 34	18 01	7 20
24	15 53	4 14	16 27	6 41	17 07	7 26	19 01	7 48
25	16 27	5 26	17 21	7 46	18 09	8 10	19 58	8 14
26	17 05	6 39	18 19	8 44	19 11	8 47	20 55	8 39
27	17 49	7 51	19 20	9 33	20 11	9 19	21 52	9 02
28	18 39	8 59	20 22	10 14	21 10	9 47	22 49	9 26
29	19 35	10 01	21 23	10 49	22 07	10 12	23 48	9 52
30	20 34	10 55	22 23	11 19	23 04	10 36	DNR	10 21
31	21 36	11 40			DNR	11 00	0 48	10 54
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	1 50	11 34	2 34	12 05	3 17	14 28	2 47	15 45
2	2 51	12 22	3 24	13 12	3 48	15 41	3 18	16 59
3	3 50	13 19	4 07	14 24	4 19	16 55	3 53	18 15
4	4 45	14 24	4 46	15 38	4 50	18 10	4 32	19 30
5	5 33	15 36	5 20	16 53	5 24	19 27	5 19	20 41
6	6 15	16 50	5 52	18 08	6 01	20 43	6 13	21 44
7	6 52	18 06	6 24	19 24	6 44	21 56	7 13	22 38
8	7 26	19 21	6 56	20 40	7 34	23 03	8 18	23 22
9	7 57	20 35	7 31	21 55	8 31	DNS	9 23	23 58
10	8 28	21 49	8 11	23 08	9 32	0 00	10 26	DNS
11	9 01	23 02	8 56	DNS	10 35	0 47	11 27	0 29
12	9 37	DNS	9 48	0 15	11 38	1 27	12 26	0 55
13	10 17	0 13	10 44	1 16	12 39	1 59	13 23	1 19
14	11 03	1 22	11 45	2 07	13 38	2 27	14 20	1 43
15	11 55	2 25	12 46	2 50	14 35	2 52	15 17	2 06
16	12 52	3 20	13 47	3 26	15 32	3 16	16 16	2 31
17	13 52	4 08	14 47	3 56	16 29	3 39	17 16	2 58
18	14 53	4 48	15 45	4 23	17 27	4 03	18 18	3 29
19	15 54	5 22	16 42	4 48	18 26	4 28	19 19	4 06
20	16 53	5 52	17 39	5 11	19 27	4 57	20 19	4 50
21	17 51	6 18	18 36	5 34	20 28	5 30	21 14	5 42
22	18 49	6 43	19 35	5 59	21 29	6 09	22 02	6 42
23	19 45	7 06	20 34	6 25	22 26	6 55	22 44	7 47
24	20 43	7 30	21 34	6 55	23 17	7 49	23 20	8 55
25	21 41	7 55	22 35	7 29	DNR	8 49	23 51	10 04
26	22 40	8 22	23 34	8 10	0 03	9 55	DNR	11 13
27	23 40	8 53	DNR	8 58	0 42	11 03	0 21	12 22
28	DNR	9 30	0 29	9 54	1 17	12 12	0 49	13 31
29	0 41	10 13	1 19	10 57	1 48	13 22	1 18	14 42
30	1 40	11 05	2 03	12 05	2 18	14 33	1 50	15 54
31			2 42	13 15			2 26	17 07

SYDNEY

AEST

MOON RISE AND SET

AEST

TOWNSVILLE

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	20 59	6 13	21 35	8 36	20 04	7 24	20 25	9 41
2	21 45	7 22	22 09	9 45	20 39	8 35	21 10	10 50
3	22 26	8 33	22 42	10 53	21 14	9 44	21 58	11 54
4	23 02	9 42	23 17	11 59	21 52	10 53	22 51	12 53
5	23 36	10 50	23 54	13 04	22 32	11 59	23 47	13 45
6	DNR	11 56	DNR	14 08	23 17	13 03	DNR	14 30
7	0 08	13 01	0 35	15 09	DNR	14 03	0 44	15 10
8	0 41	14 06	1 20	16 08	0 06	14 58	1 42	15 44
9	1 16	15 10	2 10	17 01	0 59	15 47	2 38	16 15
10	1 54	16 14	3 03	17 48	1 54	16 30	3 34	16 43
11	2 36	17 15	4 00	18 30	2 51	17 08	4 28	17 09
12	3 23	18 13	4 57	19 06	3 48	17 41	5 23	17 36
13	4 15	19 05	5 54	19 39	4 44	18 11	6 18	18 03
14	5 10	19 51	6 50	20 08	5 39	18 39	7 14	18 31
15	6 07	20 31	7 45	20 35	6 34	19 05	8 11	19 03
16	7 05	21 06	8 39	21 02	7 28	19 32	9 10	19 39
17	8 02	21 38	9 33	21 29	8 23	19 59	10 11	20 21
18	8 57	22 06	10 28	21 57	9 19	20 29	11 11	21 09
19	9 52	22 33	11 25	22 28	10 17	21 02	12 09	22 05
20	10 46	23 00	12 24	23 03	11 16	21 39	13 03	23 07
21	11 41	23 28	13 24	23 43	12 16	22 23	13 52	DNS
22	12 37	23 57	14 26	DNS	13 16	23 15	14 36	0 13
23	13 36	DNS	15 28	0 32	14 14	DNS	15 15	1 23
24	14 37	0 30	16 27	1 28	15 08	0 14	15 51	2 33
25	15 40	1 09	17 20	2 33	15 57	1 20	16 26	3 44
26	16 44	1 54	18 08	3 44	16 41	2 30	17 00	4 54
27	17 47	2 48	18 51	4 57	17 20	3 43	17 36	6 05
28	18 44	3 50	19 29	6 11	17 57	4 56	18 15	7 17
29	19 35	4 59			18 32	6 08	18 58	8 28
30	20 20	6 12			19 08	7 20	19 47	9 36
31	20 59	7 25			19 45	8 31		
	MAY		JUNE		JULY		AUGUST	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	20 39	10 40	22 19	11 43	22 57	11 16	DNR	11 03
2	21 36	11 37	23 16	12 18	23 52	11 43	0 27	11 33
3	22 34	12 26	DNR	12 48	DNR	12 09	1 25	12 06
4	23 33	13 09	0 12	13 15	0 46	12 35	2 25	12 44
5	DNR	13 45	1 07	13 41	1 42	13 04	3 27	13 30
6	0 30	14 17	2 02	14 08	2 39	13 35	4 28	14 23
7	1 26	14 46	2 57	14 35	3 39	14 10	5 26	15 25
8	2 21	15 13	3 54	15 04	4 41	14 52	6 20	16 32
9	3 16	15 39	4 52	15 37	5 43	15 42	7 08	17 44
10	4 11	16 06	5 53	16 16	6 43	16 39	7 50	18 55
11	5 06	16 34	6 55	17 00	7 40	17 43	8 27	20 06
12	6 04	17 04	7 57	17 53	8 30	18 52	9 02	21 15
13	7 03	17 39	8 55	18 52	9 15	20 02	9 35	22 24
14	8 04	18 19	9 48	19 56	9 54	21 11	10 08	23 32
15	9 05	19 06	10 35	21 04	10 29	22 19	10 43	DNS
16	10 05	19 59	11 16	22 12	11 01	23 26	11 22	0 40
17	11 00	21 00	11 53	23 20	11 34	DNS	12 05	1 46
18	11 51	22 04	12 26	DNS	12 07	0 33	12 53	2 50
19	12 35	23 12	12 59	0 26	12 42	1 40	13 47	3 50
20	13 15	DNS	13 31	1 33	13 22	2 47	14 44	4 44
21	13 51	0 20	14 05	2 40	14 07	3 53	15 44	5 31
22	14 24	1 28	14 43	3 48	14 58	4 57	16 43	6 12
23	14 57	2 36	15 25	4 57	15 53	5 56	17 42	6 47
24	15 31	3 45	16 13	6 04	16 53	6 48	18 39	7 18
25	16 08	4 55	17 07	7 08	17 53	7 34	19 34	7 46
26	16 48	6 05	18 05	8 05	18 53	8 13	20 29	8 12
27	17 34	7 15	19 05	8 56	19 51	8 47	21 23	8 38
28	18 25	8 21	20 06	9 39	20 47	9 17	22 19	9 04
29	19 21	9 23	21 05	10 16	21 42	9 44	23 15	9 32
30	20 20	10 17	22 02	10 48	22 37	10 10	DNR	10 03
31	21 20	11 04			23 31	10 36	0 13	10 39
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	1 13	11 20	1 56	11 51	2 45	14 06	2 23	15 16
2	2 13	12 09	2 47	12 57	3 20	15 16	2 57	16 27
3	3 11	13 05	3 32	14 06	3 53	16 27	3 34	17 40
4	4 07	14 10	4 13	15 17	4 27	17 40	4 16	18 52
5	4 57	15 19	4 50	16 30	5 04	18 53	5 04	20 02
6	5 41	16 31	5 25	17 42	5 44	20 07	5 59	21 05
7	6 21	17 44	6 00	18 54	6 29	21 18	7 00	22 00
8	6 57	18 56	6 35	20 07	7 21	22 24	8 03	22 46
9	7 32	20 07	7 13	21 20	8 18	23 21	9 06	23 24
10	8 06	21 18	7 55	22 31	9 18	DNS	10 08	23 57
11	8 41	22 28	8 42	23 37	10 20	0 10	11 06	DNS
12	9 19	23 37	9 34	DNS	11 21	0 51	12 03	0 26
13	10 02	DNS	10 31	0 37	12 19	1 26	12 58	0 52
14	10 49	0 44	11 30	1 29	13 16	1 57	13 52	1 18
15	11 42	1 46	12 30	2 14	14 11	2 24	14 47	1 43
16	12 39	2 42	13 29	2 51	15 06	2 50	15 43	2 10
17	13 37	3 31	14 27	3 24	16 01	3 15	16 42	2 39
18	14 37	4 13	15 23	3 53	16 56	3 41	17 41	3 13
19	15 35	4 49	16 18	4 20	17 53	4 09	18 41	3 52
20	16 32	5 21	17 12	4 45	18 52	4 39	19 40	4 37
21	17 28	5 49	18 07	5 11	19 51	5 14	20 35	5 29
22	18 23	6 16	19 03	5 38	20 50	5 55	21 25	6 28
23	19 18	6 41	20 00	6 06	21 47	6 42	22 08	7 32
24	20 12	7 07	20 58	6 38	22 39	7 36	22 47	8 38
25	21 08	7 34	21 57	7 14	23 26	8 35	23 21	9 44
26	22 06	8 04	22 55	7 56	DNR	9 39	23 53	10 51
27	23 04	8 37	23 50	8 45	0 08	10 45	DNR	11 57
28	DNR	9 15	DNR	9 41	0 45	11 52	0 24	13 03
29	0 03	10 00	0 41	10 43	1 19	12 59	0 56	14 11
30	1 01	10 52	1 27	11 48	1 51	14 07	1 30	15 20
31			2 08	12 56			2 08	16 31

Note: DNR means Moon does not rise on that day, DNS means Moon does not set. See explanation page 73.

	JANUARY		FEBRUARY		MARCH		APRIL	
	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm	Rise h mm	Set h mm
1	20 46	7 05	21 48	9 04	20 22	7 48	21 10	9 36
2	21 38	8 10	22 30	10 05	21 05	8 50	22 00	10 38
3	22 26	9 14	23 11	11 04	21 48	9 51	22 52	11 38
4	23 10	10 16	23 53	12 03	22 33	10 51	23 46	12 35
5	23 51	11 16	DNR	13 01	23 19	11 51	DNR	13 28
6	DNR	12 14	0 37	13 58	DNR	12 50	0 40	14 16
7	0 32	13 11	1 23	14 55	0 09	13 47	1 34	15 00
8	1 12	14 08	2 12	15 51	1 00	14 41	2 26	15 40
9	1 54	15 05	3 04	16 44	1 53	15 32	3 17	16 16
10	2 38	16 03	3 57	17 33	2 46	16 18	4 06	16 51
11	3 26	17 00	4 50	18 19	3 39	17 00	4 54	17 24
12	4 16	17 56	5 43	19 00	4 30	17 39	5 41	17 57
13	5 09	18 49	6 34	19 39	5 20	18 15	6 29	18 31
14	6 03	19 37	7 24	20 14	6 09	18 49	7 18	19 06
15	6 56	20 22	8 12	20 48	6 57	19 22	8 09	19 44
16	7 49	21 02	9 00	21 21	7 44	19 55	9 02	20 26
17	8 40	21 40	9 47	21 54	8 32	20 30	9 57	21 13
18	9 29	22 14	10 36	22 29	9 22	21 06	10 54	22 04
19	10 17	22 48	11 26	23 06	10 13	21 45	11 50	23 00
20	11 05	23 21	12 18	23 47	11 06	22 28	12 46	23 59
21	11 53	23 55	13 13	DNS	12 02	23 16	13 39	DNS
22	12 42	DNS	14 11	0 33	12 59	DNS	14 29	1 01
23	13 34	0 32	15 10	1 25	13 57	0 10	15 15	2 04
24	14 29	1 11	16 10	2 23	14 53	1 08	16 00	3 06
25	15 27	1 55	17 07	3 26	15 47	2 11	16 43	4 08
26	16 28	2 45	18 01	4 32	16 37	3 15	17 26	5 10
27	17 29	3 42	18 51	5 38	17 25	4 20	18 10	6 12
28	18 29	4 44	19 38	6 44	18 10	5 25	18 57	7 15
29	19 25	5 49			18 54	6 28	19 47	8 19
30	20 17	6 56			19 38	7 31	20 40	9 22
31	21 04	8 01			20 23	8 34		
	MAY		JUNE		JULY		AUGUST	
1	21 35	10 22	23 03	11 34	23 24	11 23	DNR	11 35
2	22 30	11 19	23 54	12 14	DNR	11 57	0 29	12 11
3	23 26	12 11	DNR	12 51	0 11	12 29	1 20	12 50
4	DNR	12 57	0 43	13 25	0 59	13 03	2 14	13 34
5	0 19	13 39	1 31	13 58	1 48	13 37	3 11	14 23
6	1 11	14 17	2 18	14 31	2 38	14 15	4 09	15 19
7	2 01	14 52	3 07	15 05	3 31	14 57	5 08	16 19
8	2 49	15 25	3 56	15 41	4 27	15 44	6 05	17 23
9	3 37	15 58	4 48	16 21	5 26	16 37	6 58	18 28
10	4 25	16 31	5 43	17 05	6 25	17 35	7 47	19 32
11	5 14	17 06	6 40	17 54	7 23	18 37	8 32	20 34
12	6 04	17 44	7 38	18 48	8 17	19 40	9 15	21 34
13	6 57	18 24	8 36	19 47	9 08	20 43	9 57	22 34
14	7 52	19 10	9 32	20 48	9 54	21 44	10 38	23 34
15	8 49	20 00	10 24	21 50	10 37	22 44	11 21	DNS
16	9 46	20 55	11 11	22 51	11 18	23 42	12 07	0 34
17	10 42	21 54	11 56	23 50	11 58	DNS	12 56	1 34
18	11 36	22 54	12 37	DNS	12 39	0 41	13 48	2 34
19	12 26	23 55	13 18	0 49	13 23	1 39	14 42	3 32
20	13 12	DNS	13 58	1 47	14 09	2 39	15 38	4 26
21	13 56	0 56	14 40	2 46	14 59	3 40	16 34	5 16
22	14 38	1 56	15 25	3 46	15 53	4 40	17 28	6 02
23	15 19	2 56	16 14	4 47	16 49	5 37	18 20	6 43
24	16 01	3 56	17 07	5 49	17 45	6 31	19 10	7 20
25	16 46	4 57	18 02	6 50	18 41	7 21	19 59	7 55
26	17 34	5 59	18 59	7 47	19 35	8 05	20 47	8 28
27	18 25	7 02	19 56	8 40	20 27	8 45	21 34	9 00
28	19 20	8 05	20 52	9 27	21 16	9 21	22 22	9 33
29	20 16	9 05	21 45	10 10	22 04	9 55	23 12	10 08
30	21 13	10 00	22 35	10 48	22 52	10 28	DNR	10 45
31	22 09	10 50			23 40	11 01	0 04	11 26
	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	0 59	12 13	1 37	12 46	2 46	14 38	2 46	15 25
2	1 55	13 04	2 31	13 48	3 29	15 39	3 28	16 28
3	2 52	14 01	3 22	14 51	4 12	16 41	4 14	17 32
4	3 49	15 03	4 10	15 54	4 54	17 44	5 03	18 38
5	4 44	16 07	4 56	16 57	5 39	18 49	5 58	19 44
6	5 35	17 12	5 39	18 00	6 28	19 55	6 56	20 46
7	6 22	18 16	6 23	19 04	7 20	21 01	7 56	21 42
8	7 07	19 19	7 07	20 08	8 16	22 04	8 57	22 33
9	7 50	20 21	7 53	21 12	9 14	23 02	9 54	23 17
10	8 33	21 23	8 42	22 16	10 13	23 54	10 49	23 56
11	9 17	22 25	9 35	23 19	11 11	DNS	11 41	DNS
12	10 03	23 27	10 30	DNS	12 06	0 41	12 30	0 32
13	10 52	DNS	11 27	0 18	12 58	1 21	13 18	1 05
14	11 43	0 28	12 24	1 11	13 48	1 58	14 05	1 37
15	12 38	1 28	13 19	2 00	14 36	2 33	14 53	2 10
16	13 34	2 23	14 12	2 43	15 24	3 05	15 43	2 44
17	14 29	3 14	15 03	3 22	16 11	3 37	16 34	3 20
18	15 23	4 01	15 52	3 57	17 00	4 10	17 28	3 59
19	16 16	4 42	16 40	4 31	17 50	4 45	18 24	4 43
20	17 06	5 20	17 27	5 03	18 42	5 22	19 20	5 32
21	17 55	5 56	18 15	5 36	19 36	6 03	20 16	6 26
22	18 43	6 29	19 04	6 09	20 32	6 48	21 08	7 24
23	19 30	7 01	19 54	6 44	21 27	7 38	21 57	8 23
24	20 18	7 34	20 47	7 23	22 21	8 33	22 43	9 23
25	21 07	8 08	21 41	8 04	23 11	9 30	23 25	10 22
26	21 58	8 44	22 36	8 51	23 59	10 29	DNR	11 20
27	22 51	9 23	23 31	9 42	DNR	11 28	0 05	12 18
28	23 46	10 07	DNR	10 37	0 43	12 27	0 44	13 16
29	DNR	10 55	0 24	11 36	1 25	13 26	1 24	14 15
30	0 42	11 48	1 14	12 36	2 05	14 25	2 07	15 16
31			2 02	13 37			2 53	16 20

MOON

GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY	
	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "
1	08 16 03	+22 47 24	11 48 15	+06 51 57	12 19 55	+03 13 58	15 36 37	-17 12 54	18 07 07	-24 37 25	21 27 31	-19 48 21	23 31 59	-08 43 39
2	09 17 23	+19 54 51	12 42 06	+00 54 14	13 14 43	-02 58 59	16 33 44	-21 02 12	19 05 12	-24 55 16	22 16 21	-16 07 02	00 15 34	-03 50 51
3	10 16 07	+15 46 48	13 34 37	-04 58 57	14 08 51	-08 53 53	17 31 16	-23 03 08	20 01 07	-23 52 39	23 02 29	-11 50 20	00 58 32	+01 09 23
4	11 11 56	+10 44 19	14 26 42	-10 28 24	15 03 02	-14 10 07	18 28 25	-24 41 42	20 54 09	-21 40 55	23 46 43	-07 09 28	01 41 51	+06 08 32
5	12 05 15	+05 09 40	15 19 11	-15 18 09	15 57 44	-18 31 25	19 24 14	-24 30 10	21 44 09	-18 33 09	00 29 55	-02 13 55	02 26 29	+10 57 32
6	12 56 54	-00 36 27	16 12 32	-19 14 56	16 53 05	-21 45 59	20 17 57	-23 05 45	22 31 24	-14 42 06	01 13 00	+02 47 35	03 13 21	+15 25 50
7	13 47 52	-06 15 33	17 06 52	-22 08 06	17 48 47	-23 46 30	21 09 07	-20 38 42	23 16 29	-10 19 05	01 56 54	+07 46 06	04 03 15	+19 20 25
8	14 39 05	-11 31 06	18 01 53	-23 50 12	18 44 10	-24 30 23	21 57 41	-17 20 20	00 00 10	-05 34 04	02 42 31	+12 31 28	04 56 39	+22 25 45
9	15 31 16	-16 07 54	18 56 51	-24 17 54	19 38 28	-23 59 41	22 44 00	-13 21 50	00 43 15	-00 36 15	03 30 39	+16 51 29	05 53 32	+24 24 51
10	16 24 52	-19 52 06	19 50 53	-23 32 38	20 30 59	-22 20 37	23 28 33	-08 53 43	01 26 37	+04 25 14	04 21 53	+20 31 38	06 53 04	+25 02 22
11	17 19 48	-22 31 49	20 43 11	-21 40 26	21 21 16	-19 42 13	00 12 02	-04 05 51	02 11 03	+09 20 31	05 16 26	+23 15 43	07 53 50	+24 08 43
12	18 15 30	-23 58 44	21 33 16	-18 50 43	22 09 16	-16 15 04	00 55 11	+00 52 10	02 57 21	+13 58 19	06 13 53	+24 47 55	08 54 07	+21 43 45
13	19 11 01	-24 09 38	22 21 02	-15 14 44	22 55 13	-12 10 10	01 38 43	+05 50 33	03 46 10	+18 05 36	07 13 09	+24 56 08	09 52 35	+17 57 11
14	20 05 18	-23 07 08	23 06 45	-11 04 00	23 39 35	-07 38 16	02 23 26	+10 38 54	04 37 56	+21 27 46	08 12 45	+23 35 22	10 48 39	+13 06 08
15	20 57 30	-20 59 01	23 50 53	-06 29 28	00 22 59	-02 49 34	03 10 01	+15 05 45	05 32 39	+23 49 43	09 11 16	+20 49 22	11 42 28	+07 31 12
16	21 47 13	-17 56 14	00 34 09	-01 41 10	01 06 07	+02 06 03	03 59 05	+18 58 26	06 29 45	+24 57 53	10 07 47	+16 49 32	12 34 41	+01 33 34
17	22 34 29	-14 10 49	01 17 18	+01 31 35	01 49 44	+06 58 53	04 51 00	+22 03 12	07 28 14	+24 42 54	11 02 09	+11 52 04	13 26 17	-04 26 34
18	23 19 42	-09 54 14	02 01 11	+07 59 45	02 34 37	+11 38 50	05 45 46	+24 06 01	08 26 46	+23 01 56	11 54 46	+06 15 15	14 18 14	-10 10 10
19	00 03 32	-05 16 42	02 46 40	+12 33 42	03 21 31	+15 54 58	06 42 54	+24 54 19	09 24 16	+19 59 24	12 46 25	+00 17 55	15 11 24	-15 19 05
20	00 46 47	-00 27 18	03 34 37	+16 42 25	04 11 05	+19 35 02	07 41 27	+24 19 11	10 20 07	+15 45 54	13 38 07	-05 40 54	16 06 22	-19 36 06
21	01 30 19	+04 25 30	04 25 48	+20 12 41	05 03 47	+22 25 18	08 40 16	+22 17 36	11 14 20	+10 36 18	14 30 49	-11 21 51	17 03 10	-22 45 42
22	02 15 07	+09 12 51	05 20 38	+22 48 54	05 59 38	+24 11 13	09 38 20	+18 53 29	12 07 24	+04 48 11	15 25 16	-16 25 11	18 01 14	-24 36 07
23	03 02 07	+13 44 32	06 19 04	+24 14 08	06 58 10	+24 39 03	10 35 07	+14 17 29	13 00 07	-01 18 57	16 21 51	-20 31 38	18 59 26	-25 01 37
24	03 52 15	+17 47 43	07 20 16	+24 13 05	07 58 21	+23 38 56	11 30 36	+08 45 47	13 53 23	-07 23 56	17 20 16	-23 24 24	19 56 23	-24 04 02
25	04 46 11	+21 06 24	08 22 46	+22 36 37	08 58 52	+21 07 49	12 25 15	+02 38 48	14 48 02	-13 04 27	18 19 34	-24 52 14	20 50 57	-21 52 15
26	05 44 06	+23 21 57	09 24 54	+19 25 47	09 58 35	+17 11 30	13 19 46	-03 40 02	15 44 35	-17 58 01	19 18 19	-24 52 04	21 42 32	-18 39 37
27	06 45 26	+24 15 50	10 25 24	+14 53 08	10 56 51	+12 04 31	14 14 54	-09 45 45	16 43 01	-21 44 20	20 15 05	-23 29 30	22 31 07	-14 40 56
28	07 48 41	+23 34 38	11 23 41	+09 20 21	11 53 38	+06 08 18	15 11 17	-15 13 36	17 42 39	-24 08 18	21 08 52	-20 56 37	23 17 07	-10 10 18
29	08 51 55	+21 15 21			12 49 21	-00 11 33	16 09 06	-19 41 29	18 42 12	-25 02 58	21 59 23	-17 28 26	00 01 14	-05 19 57
30	09 53 24	+17 27 39			13 44 41	-06 28 08	17 08 01	-22 52 32	19 40 12	-24 30 37	22 46 52	-13 19 47	00 44 19	-00 20 16
31	10 52 13	+12 31 31			14 40 17	-12 15 55			20 35 29	-22 41 05			01 27 16	+04 39 37

AUGUST			SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		MOON PHASES (AEST)		
											Lunation	New Moon d h:m	First Quarter d h:m
1	02 11 01	+ 09 30 58	05 10 29	+ 23 22 49	07 42 51	+ 24 49 12	11 10 24	+ 10 57 19	13 30 58	- 05 26 41	977		
2	02 56 30	+ 14 04 20	06 06 28	+ 24 57 51	08 41 37	+ 22 38 10	12 04 21	+ 04 52 09	14 25 25	- 11 32 36	978	Jan 13 23:29	Jan 22 03:46
3	03 44 36	+ 18 08 37	07 05 09	+ 25 12 13	09 39 56	+ 19 01 37	12 58 25	- 01 36 45	15 22 24	- 17 00 23	979	Feb 12 17:41	Feb 20 22:02
4	04 36 00	+ 21 30 18	08 05 23	+ 23 56 14	10 37 10	+ 14 09 50	13 53 29	- 08 04 46	16 22 11	- 21 24 42	980	Mar 14 12:02	Mar 22 12:28
5	05 31 01	+ 23 53 40	09 05 44	+ 21 07 53	11 33 14	+ 08 19 58	14 50 18	- 14 04 53	17 24 10	- 24 23 43	981	Apr 13 05:21	Apr 20 22:48
6	06 29 20	+ 25 02 23	10 05 00	+ 16 54 49	12 28 33	+ 01 54 39	15 49 19	- 19 10 10	18 26 54	- 25 44 12	982	May 12 20:45	May 20 05:42
7	07 29 52	+ 24 43 01	11 02 34	+ 11 33 33	13 23 48	- 04 39 59	16 50 17	- 22 57 18	19 28 25	- 25 24 58	983	Jun 11 09:46	Jun 18 10:29
8	08 31 04	+ 22 49 29	11 58 28	+ 05 26 59	14 19 45	- 10 56 27	17 52 12	- 25 10 51	20 26 58	- 23 36 16	984	Jul 10 20:26	Jul 17 14:47
9	09 31 20	+ 19 25 57	12 53 16	- 00 58 58	15 17 01	- 16 28 30	18 53 27	- 25 46 07	21 21 37	- 20 35 20	985	Aug 09 05:15	Aug 15 20:12
10	10 29 36	+ 14 46 34	13 47 43	- 07 18 09	16 15 44	- 20 53 38	19 52 25	- 24 49 12	22 12 17	- 16 40 56	986	Sep 07 13:10	Sep 14 04:08
11	11 25 35	+ 09 12 25	14 42 38	- 13 06 22	17 15 32	- 23 55 38	20 48 00	- 22 33 44	22 59 33	- 12 09 57	987	Oct 06 21:18	Oct 13 15:33
12	12 19 41	+ 03 07 25	15 38 35	- 18 02 43	18 15 23	- 25 26 26	21 39 50	- 19 16 20	23 44 16	- 07 16 07	988	Nov 05 06:34	Nov 12 06:52
13	13 12 41	- 03 04 38	16 35 43	- 21 50 30	19 14 02	- 25 26 39	22 28 14	- 15 13 04	00 27 25	- 02 10 23	989	Dec 04 17:34	Dec 12 01:49
14	14 05 28	- 09 01 45	17 33 43	- 24 18 14	20 10 17	- 24 04 18	23 13 52	- 10 37 49	01 10 02	+ 02 58 03			
15	14 58 56	- 14 24 15	18 31 42	- 25 20 36	21 03 28	- 21 31 58	23 57 36	- 05 42 08	01 53 04	+ 08 00 29			
16	15 53 42	- 18 54 53	19 28 37	- 24 58 49	21 53 27	- 18 03 53	00 40 21	- 00 35 58	02 37 26	+ 12 47 39			
17	16 49 55	- 22 19 03	20 23 26	- 23 20 00	22 40 36	- 13 53 47	01 23 00	+ 04 31 28	03 23 59	+ 17 08 46			
18	17 47 14	- 24 25 54	21 15 33	- 20 35 17	23 25 30	- 09 14 05	02 06 27	+ 09 30 43	04 13 20	+ 20 51 09			
19	18 44 46	- 25 09 47	22 04 51	- 16 57 46	00 08 55	- 04 15 51	02 51 28	+ 14 11 23	05 05 45	+ 23 40 30			
20	19 41 21	- 24 31 26	22 51 35	- 12 40 41	00 51 39	+ 00 50 44	03 38 44	+ 18 21 42	06 01 00	+ 25 22 29			
21	20 35 56	- 22 37 43	23 36 18	- 07 56 30	01 34 31	+ 05 55 49	04 28 43	+ 21 48 32	06 58 11	+ 25 45 21	977	Jan 29 08:50	Jan 06 13:55
22	21 27 51	- 19 40 07	00 19 41	- 02 56 37	02 18 16	+ 10 49 21	05 21 28	+ 24 18 13	07 56 02	+ 24 43 02	978	Feb 27 19:17	Feb 04 23:33
23	22 16 55	- 15 52 19	01 02 29	+ 02 08 28	03 03 39	+ 15 20 35	06 16 35	+ 25 38 07	08 53 09	+ 22 16 54	979	Mar 29 04:25	Mar 06 11:24
24	23 03 27	- 11 28 09	01 45 30	+ 07 08 50	03 51 16	+ 19 17 51	07 13 10	+ 25 39 00	09 48 37	+ 18 35 30	980	Apr 27 13:00	Apr 05 01:29
25	23 47 59	- 06 40 24	02 29 31	+ 11 54 36	04 41 30	+ 22 28 40	08 10 03	+ 24 17 00	10 42 06	+ 13 52 20	981	May 26 21:51	May 04 17:16
26	00 31 16	- 01 40 24	03 15 15	+ 16 15 28	05 34 24	+ 24 40 20	09 06 10	+ 21 34 30	11 33 54	+ 08 23 29	982	Jun 25 07:42	Jun 03 10:05
27	01 14 06	+ 03 21 47	04 03 23	+ 20 00 11	06 29 36	+ 25 41 11	10 00 53	+ 17 39 27	12 24 47	+ 02 26 01	983	Jul 24 19:07	Jul 03 03:19
28	01 57 20	+ 08 16 52	04 54 20	+ 22 56 27	07 26 17	+ 25 22 31	10 54 08	+ 12 43 53	13 15 44	- 03 42 14	984	Aug 23 08:29	Aug 01 20:22
29	02 41 50	+ 12 55 29	05 48 13	+ 24 51 14	08 23 26	+ 23 40 16	11 46 19	+ 07 02 34	14 07 49	- 09 42 23	985	Sep 21 23:59	Sep 30 03:03
30	03 28 25	+ 17 07 28	06 44 40	+ 25 32 04	09 20 08	+ 20 36 10	12 38 17	+ 00 52 31	15 02 03	- 15 13 51	986	Oct 21 17:20	Oct 29 15:28
31	04 17 49	+ 20 41 06			10 15 48	+ 16 17 40			15 59 05	- 19 54 40	987	Nov 20 11:34	Nov 28 01:46
											988	Dec 20 05:10	Dec 27 10:31
											989		

MOON DISTANCE				(AEST)	
APOGEE				PERIGEE	
d hh		d hh		d hh	
Jan	18 19	Jul	30 12	Jan	2 17
Feb	15 08	Aug	27 04	Jan	30 19
Mar	14 11	Sep	23 13	Feb	28 06
Apr	10 15	Oct	20 15	Mar	28 18
May	8 05	Nov	16 21	Apr	26 02
Jun	4 23	Dec	14 14	May	24 02
Jul	2 18			Jun	19 17
				Jul	14 23
				Aug	11 09
				Sep	8 13
				Oct	6 23
				Nov	4 11
				Dec	2 19
				Dec	30 11

LUNAR OCCULTATIONS 2002

INTRODUCTION

An occultation is when a body passes in front of a more distant astronomical object. As viewed from Earth, no Solar System body occults more stars, more often, than our own Moon. The reasons for this are:

1. Its large angular size. Although the Moon is small in comparison to the planets, it appears large (0.5° wide) because of its proximity. The Moon travels along a 0.5° wide path across the sky, as does the Sun.
2. The rapid motion of the Moon across the sky. It completes one orbit about every 28 days.
3. With it moving approximately in the plane of the ecliptic, as do most Solar System bodies, each month the Moon crosses the heavily star populated Milky Way. It also occasionally occults the Sun and the planets. An eclipse of the Sun is indeed the most spectacular lunar occultation!

From month to month the Moon does not occult the same stars. In fact over a number of years it drifts in declination between plus and minus 28° . The brighter stars the Moon occults are listed in the Zodiacal Catalogue (ZC). There are about 3500 stars in the ZC.

The Moon moves from west to east, so it rises and sets later from day to day. From just after New Moon to just before Full Moon, stars being occulted will disappear behind part of the dark limb and reappear from the bright limb. The limb is another way of saying the edge of the Moon. After Full Moon a star will disappear on the bright limb and reappear on the dark limb. There is no dark limb at the time of Full Moon.

Dark limb events, in particular disappearances, are the easiest to observe. Following a star until it 'winks out' is much easier than scanning the lunar limb, waiting for it to suddenly reappear. The brighter the star, the more spectacular the event. The following tables present the easier to observe occultations for 2002 as predicted for **Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne and Sydney**. Both events, the disappearance and reappearance, are not necessarily included. An event may not be present because:

1. The Moon is in daylight
2. The Moon is too close to or below the horizon.
3. For faint stars, events on a bright limb (in particular reappearances) are difficult to observe and have been omitted.

THE TIMING OF OCCULTATIONS.

Besides being a spectacular event, occultations is an area in which the amateur can make a scientific contribution. The exact timing of when a star goes into or out of occultation helps astronomers in refining their knowledge of the Moon's position and the shape of the limb.

TIMING EQUIPMENT. For a single event, such as a normal occultation, a stop-watch and the telephone time signal as a reference are required. For multiple events, the amateur may tape record simultaneously a shortwave radio time signal with his own voice calling out the events (e.g., star gone ... now!). The tape would be later played back (often at a slower speed) and the precise times determined. An accuracy of within 0.2 seconds is not unusual for the experienced observer.

TELESCOPE REQUIREMENTS. These vary greatly with the brightness of the star being observed, the brightness of the Moon (how close to Full Moon) and whether the event is on a bright or dark limb. Disappearances of first magnitude stars on the dark limb can be observed with the naked eye!

For further information on timing methods for occultations it would be worth contacting your local astronomical society (p. 138).

LUNAR OCCULTATION TABLES

The faintest stars, which have occultation predictions on the following pages, are approximately 7th magnitude. The criteria for selection are complex involving the Sun and Moon altitude, star magnitude and whether it is a bright or dark limb event.

EXPLANATION

AEST	the date and time of the occultation, hr & min are in AEST for all except Adelaide and Darwin which are ACST
OBJECT	n, nn, nnn, nnnn ZC catalogue number nnnnn or nnnnnn SAO catalogue number X nnnnn USNO XZ catalogue number name of planet, satellite or Messier (Mnnn) object.
PD	event, consisting of two letters. The first letter is the type of Event: 'D' = Disappearance and 'R' = Reappearance. The second letter represents: 'D' = Dark limb, 'B' = a bright limb event. A 'G' indicates a graze at or near the location.
Mag	magnitude of the star.
Elg	elongation or separation of the Moon from the Sun as measured in degrees.
Alt.	altitude of the Moon during the occultation.
P.A.	position angle is the position the event occurs on the limb of the Moon (measured as degrees east of lunar north).
A	coefficient of longitude (see below)
B	coefficient of latitude (see below) **** NB. For some stars, close to 'grazing', A and B values become useless, and no values are recorded.

CALCULATING EVENT TIME FOR OTHER LOCATIONS

Unless the event is close to a 'graze' (PA is close to 0° or 180°) this method will give a good approximation for any location within about 500km from the city's table you are working from. The formula is:

Predicted Time at your location
= Time from Table + (A x n) + (B x p)

where 'n' and 'p' are the **change** in longitude and latitude respectively (in decimal degrees).

'n' is positive (+) if east, negative (-) if west

'p' is positive (+) if north, negative (-) if south.

The values for A and B are taken from the tables.

It is best to use data for the city which you are closest to.

WORKED EXAMPLE

An observer wishes to calculate a more accurate time for the disappearance of ZC219 on September 24 for their location in Albury NSW ($146^\circ 55' \text{ E}$, $36^\circ 05' \text{ S}$), see page 130. Canberra is the closest city, therefore we start with the data from its table.

The change in longitude from Canberra (decimal degrees)
= $149^\circ.13 - 146^\circ.92 = -2^\circ.21$ — 'n' (-)

The change in latitude from Canberra (decimal degrees)
= $35^\circ.25 - 36^\circ.08 = -0^\circ.83$ — 'p' (-)

From the Canberra table, the time of the event is 01:10 AEST and the values of A and B are +1.0 and +2.2 respectively.

Therefore the equation becomes:

$$\begin{aligned} & 01:10 + (1.0 * -2^\circ.21) + (2.2 * -0^\circ.83) \\ & = 01:10 + (-2.2) + (-1.8) \\ & = 01:10 - 4.0 = 01:06 \end{aligned}$$

The event will be visible from Albury approximately 4 minutes earlier than Canberra, i.e., about 1:04am (AEST) on September 24th.

Lunar occultation predictions were calculated using Occult version 4 by D. Herald, PO Box 254 Woden ACT 2606.
herald@canberra.DIALix.oz.au



LUNAR OCCULTATION TABLE

ADELAIDE (34° 58' S, 138° 38'E)

ACST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	ACST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	ACST	OBJECT	PD	Mag	Elg	Alt	PA	A	B
Jan 02 01:36	1334	RD	7.0	150	32	274	+2.1	-0.5	May 26 20:01	2322	RD	4.1	178	33	251	+1.2	-0.5	Sep 12 21:46	2302	DD	2.6	73	25	113	+0.7	+0.4
Jan 05 00:06	1707	RD	5.3	110	7	6	+0.6	-4.9	May 29 00:58	2659	RD	6.2	152	71	220	+3.1	+3.3	Sep 12 21:46	2303	DD	4.8	73	25	112	+0.7	+0.4
Jan 08 03:36	2072	RD	6.6	69	30	221	+4.1	+3.8	May 30 02:34	2834	DB	5.0	139	77	61	+2.4	+1.3	Sep 12 22:45	2302	RB	2.6	74	13	266	0.0	+1.2
Jan 09 03:41	159185	RD	7.4	57	24	243	+1.1	-0.3	May 30 03:52	2835	RD	7.3	139	76	312	+2.9	-2.6	Sep 12 22:45	2303	RB	4.8	74	13	267	0.0	+1.2
Jan 10 03:59	2331	RD	6.3	44	20	292	+0.1	-1.5	May 30 03:58	2834	RD	5.0	139	75	286	+2.5	-0.5	Sep 14 23:15	186240	DD	7.3	99	32	84	+0.6	+1.3
Jan 17 20:38	3356	DD	5.8	43	16	50	0.0	+2.0	Jun 01 00:04	3092	RD	6.2	116	27	289	+0.4	-1.9	Sep 15 19:06	187465	DD	7.4	110	78	53	+2.5	+2.0
Jan 21 20:35	110154	DD	7.4	87	35	96	+2.1	+0.9	Jun 01 05:37	3116	RD	6.6	114	73	199	+0.9	+3.9	Sep 15 21:58	2767	DD	6.3	111	58	51	+1.2	+2.6
Jan 22 21:43	384	DD	5.6	98	27	5	+0.9	+3.8	Jun 02 01:40	164829	RD	7.1	104	35	280	+1.0	-1.7	Sep 15 23:09	2771	DD	5.6	111	44	49	+0.5	+2.5
Jan 23 23:48	505	DD	7.0	111	11	108	+0.8	+0.7	Jun 02 01:41	3228	RD	7.2	104	35	280	+1.0	-1.7	Sep 16 00:10	2771	RB	5.6	112	32	287	+1.0	+0.6
Jan 25 00:09	646	DD	6.1	123	13	25	+1.7	+3.2	Jun 02 06:05	3243	RD	7.3	103	71	234	+1.9	+1.8	Sep 16 00:47	187660	DD	7.3	112	25	44	-0.3	+2.3
Jan 27 23:48	1117	DD	5.0	161	30	59	+2.4	+1.1	Jun 03 04:48	3358	RD	6.9	92	58	310	+4.6	-6.8	Sep 16 01:49	2790	DD	6.3	113	13	68	-0.3	+1.5
Jan 30 22:52	1533	RD	7.3	157	22	324	+1.2	-2.2	Jun 05 03:39	128707	RD	6.9	70	25	280	+1.1	-1.9	Sep 18 20:24	164567	DD	7.3	145	62	123	+2.8	-3.5
Jan 31 21:46	1651	RD	3.9	143	4	329	+0.5	-2.3	Jun 08 05:30	384	RD	5.6	36	13	296	+1.5	-3.1	Sep 19 21:13	3304	DD	6.4	157	60	85	+2.3	-0.5
Feb 01 00:17	1665	RD	7.0	142	31	345	+0.8	-2.7	Jun 15 18:17	80882	DD	7.3	55	28	86	+2.0	+1.0	Sep 20 23:30	3428	DD	5.0	168	65	99	+3.4	-0.7
Feb 04 02:48	2035	RD	7.2	100	44	290	+1.3	-1.5	Jun 15 18:34	1408	DD	7.4	55	26	134	+0.9	-0.5	Sep 21 00:31	3428	RB	5.0	169	62	186	+0.2	+3.7
Feb 08 03:42	2567	RD	7.2	51	22	318	-0.3	-2.2	Jun 16 18:34	1533	DD	7.3	68	35	97	+2.0	+0.4	Sep 21 03:45	3446	DD	7.2	170	29	40	+0.4	+2.3
Feb 22 21:00	880	DD	6.8	113	29	37	+2.3	+2.1	Jun 18 22:44	1773	DD	5.0	96	23	190	-0.7	-5.1	Sep 22 23:15	95	RD	7.0	168	48	198	+0.7	+2.3
Feb 22 21:24	882	DD	5.0	114	27	73	+2.2	+1.0	Jun 18 23:06	1773	RB	5.0	96	19	231	+1.7	+5.1	Sep 23 22:55	212	RD	7.2	158	35	225	+1.1	+0.7
Feb 22 22:44	882	RB	5.0	114	18	283	+1.4	+0.6	Jun 19 23:15	139236	DD	7.1	110	31	138	+0.8	-0.7	Sep 24 00:36	219	DB	4.8	157	47	355	-0.4	+3.8
Feb 23 19:14	1030	RB	3.1	126	26	248	+1.8	0.0	Jun 22 18:33	2259	DD	6.8	148	40	134	+0.5	-2.1	Sep 24 01:27	219	RD	4.8	157	49	286	+4.0	-1.1
Feb 23 21:38	78778	DD	6.8	126	29	34	+2.7	+2.6	Jun 23 19:44	2415	DD	7.3	162	46	160	-0.1	-3.2	Sep 26 04:38	450	RD	6.4	134	34	173	0.0	+4.9
Feb 23 23:21	78827	DD	7.4	127	21	65	+2.0	+1.6	Jun 25 23:36	187431	RD	7.3	171	70	290	+2.0	-1.5	Sep 28 02:44	709	DB	4.3	112	27	89	+2.2	-0.7
Feb 25 21:58	1334	DD	7.0	153	32	116	+2.0	-0.9	Jun 26 00:30	187465	RD	7.4	171	78	229	+2.4	+2.3	Sep 28 04:06	709	RD	4.3	112	32	224	+1.8	+1.1
Feb 27 02:55	1484	DD	3.5	169	23	140	+0.6	-0.6	Jun 26 02:10	2761	RD	6.6	170	72	262	+2.1	+0.8	Sep 28 04:06	76720	RD	7.0	112	32	224	+1.8	+1.1
Feb 27 03:54	1484	RB	3.5	169	14	276	+0.8	+0.9	Jun 26 03:17	2767	RD	6.3	170	59	234	+1.3	+2.4	Oct 02 04:36	1274	RD	5.7	64	13	311	+1.6	-2.1
Mar 01 03:35	1739	RD	6.4	160	42	301	+1.4	-0.4	Jun 26 04:27	2771	RD	5.6	169	45	237	+0.7	+2.2	Oct 12 13:05	2672	DD	2.8	78	35	151	-0.3	-3.2
Mar 02 00:44	1854	RD	6.8	147	47	318	+1.2	-1.9	Jun 26 06:02	187660	RD	7.3	169	26	243	+0.1	+1.8	Oct 12 13:49	2672	RB	2.8	78	44	232	+2.0	+0.7
Mar 05 02:55	2246	RD	7.3	106	55	328	+0.7	-2.6	Jun 27 00:35	2907	RD	6.2	158	70	274	+2.2	-0.7	Oct 12 22:32	2719	DD	5.8	81	26	35	-0.4	+2.8
Mar 07 02:12	185512	RD	7.4	82	29	241	+1.1	-0.2	Jun 28 21:37	164516	RD	6.9	136	13	284	-0.1	-1.6	Oct 13 19:37	2861	RB	5.6	92	71	299	+2.8	-1.2
Mar 08 03:10	2692	DB	5.5	69	30	83	+0.7	-0.9	Jun 28 23:13	164567	RD	7.3	135	31	204	+1.4	+2.2	Oct 13 20:06	2864	RB	4.6	92	66	252	+1.8	+1.5
Mar 08 03:59	2689	RD	6.8	69	40	276	+1.0	-1.3	Jun 29 04:26	3191	RD	7.4	134	70	212	+1.2	+2.8	Oct 14 22:18	3009	DD	7.4	105	50	61	+1.0	+1.9
Mar 08 04:16	2692	RD	5.5	69	43	300	+0.7	-2.1	Jun 30 00:04	3304	RD	6.4	123	30	274	+0.9	-1.5	Oct 15 22:54	3150	DD	6.6	116	50	18	+0.1	+3.4
Mar 08 04:43	2694	RD	6.5	69	49	264	+1.5	-0.8	Jul 14 19:59	1621	DD	7.2	52	17	103	+0.8	+0.6	Oct 15 23:23	164449	DD	7.2	117	45	77	+1.2	+1.5
Mar 09 02:34	2836	RD	5.5	58	13	225	+0.7	+0.4	Jul 15 19:47	1739	DD	6.4	66	31	101	+1.3	+0.6	Oct 16 19:39	3265	DD	6.5	127	65	357	+0.2	+6.3
Mar 20 19:46	76645	DD	7.1	70	21	86	+1.6	+1.1	Jul 16 20:38	1856	DD	6.8	80	36	174	+0.3	-2.8	Oct 17 01:30	3284	DD	7.0	129	26	97	+0.9	+1.1
Mar 23 20:12	1117	RB	5.0	106	30	228	+2.8	+1.7	Jul 17 19:39	1976	DD	7.0	93	57	162	+0.8	-2.2	Oct 18 21:08	3506	DD	6.1	149	57	81	+2.5	-0.1
Mar 25 22:30	1408	DD	7.4	134	34	82	+2.4	+0.6	Jul 17 20:14	1978	DD	6.6	93	52	159	+0.9	-2.5	Oct 19 23:13	128823	DD	7.2	161	56	18	+0.8	+2.7
Mar 26 20:33	1533	DD	7.3	147	32	82	+2.0	-0.5	Jul 18 20:14	2097	DD	6.8	106	63	101	+2.2	-0.1	Oct 20 00:33	76	DD	5.9	161	49	78	+2.3	+1.2
Mar 27 19:10	1651	DD	3.9	160	15	63	+0.9	-0.3	Jul 18 23:52	2110	DD	6.3	107	25	85	+0.7	+1.4	Oct 24 22:22	634	RD	5.3	144	9	279	+1.2	-1.6
Mar 27 19:50	1651	RB	3.9	160	23	346	+0.8	-2.8	Jul 19 19:09	2218	RB	5.5	119	69	271	+2.4	-0.4	Oct 25 00:51	656	DB	4.2	143	28	62	+1.6	+0.2
Mar 28 03:52	1689	DD	5.2	164	16	106	+0.6	+0.6	Jul 19 19:25	159358	DD	7.2	119	70	149	+1.1	-2.6	Oct 25 02:12	657	RD	5.3	143	33	226	+1.8	+1.1
Mar 30 22:18	2043	RD	6.5	154	33	347	0.0	-2.7	Jul 19 22:16	2232	DD	7.2	120	56	176	+1.1	-5.5	Oct 25 02:20	656	RD	4.2	143	33	247	+2.2	+0.6
Mar 30 22:45	2047	RD	6.6	154	38	334	+0.4	-2.4	Jul 22 03:32	185674	DD	7.3	147	19	58	-0.2	+2.0	Oct 27 00:44	932	RD	7.3	120	12	237	+0.7	-0.1
Apr 01 02:57	159188	RD	7.4	139	70	346	+0.7	-3.5	Jul 23 18:27	2834	DD	5.0	169	24	113	+0.1	-1.7	Oct 28 03:01	1089	RD	6.7	108	22	278	+2.0	-1.0
Apr 01 03:23	2193	RD	6.1	139	70	311	+1.7	-1.5	Jul 23 18:27	2835	DD	7.3	169	24	91	+0.4	-1.1	Oct 28 03:26	79164	RD	7.4	108	24	316	+2.6	-2.2
Apr 02 04:27	159860	RD	7.4	125	73	277	+2.3	-0.1	Jul 26 05:05	3150	RD	6.6	163	40	224	+0.4	+2.3	Oct 29 02:56	79980	RD	7.3	96	17	228	+0.9	+0.3
Apr 04 00:30	186366	RD	7.3	101	24	274	+0.3	-1.2	Jul 26 21:00	3243	RD	7.3	154	20	230	+0.7	+0.2	Nov 09 19:59	2809	RB	4.9	61	42	264	+1.0	+1.2
Apr 05 02:50	187779	RD	7.4	88	41	318	+0.3	-3.1	Jul 27 01:22	3265	RD	6.5	153	68	265	+2.5	-0.1	Nov 12 20:53	164829	DD	7.1	97	58	52	+1.3	+2.1
Apr 24 01:37	1621	DD	7.2	130	14	88	+0.8	+1.2	Jul 29 02:35	3506	RD	6.1	130	58	255	+2.4	+0.3	Nov 12 20:53	3228	DD	7.2	97	58	52	+1.3	+2.1
Apr 25 00:22	1739	DD	6.4	144	39	111	+1.5	0.0	Jul 30 01:19	66	RD	7.1	120	37	186	+0.3	+3.1	Nov 13 23:56	3358	DD	6.9	109	28	120	+1.7	+0.1
Apr 27 04:08	2008	DD	6.6	173	27	149	+0.7	-1.2	Jul 30 05:29	76	RD	5.9	118	52	311	+9.4	-6.5	Nov 14 21:02	146786	DD	7.4	119	61	35	+1.3	+2.3
Apr 27 23:39	2110	RD	6.3	173	64	240	+3.8	+1.7	Aug 03 03:43	517	RD	6.1	74													

LUNAR OCCULTATION TABLE

BRISBANE (27° 30' S, 153° 01'E)

AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B
Jan 02 02:33	1334	RD	7.0	150	40	304	+1.9	-0.9	Jan 01 03:30	3106	DB	5.2	115	75	112	+3.3	-2.0	Sep 13 22:38	2450	DD	7.5	86	20	134	+0.9	-0.7
Jan 04 23:43	1701	RD	4.8	110	11	311	+0.6	-1.9	Jan 01 04:39	3106	RD	5.2	115	82	202	+1.3	+3.9	Sep 14 23:58	186240	DD	7.3	99	15	81	0.0	+1.1
Jan 10 02:55	159765	RD	7.4	45	11	336	-0.6	-2.4	Jan 05 04:01	44	RD	7.4	70	38	205	+0.9	+2.0	Sep 15 20:35	187465	DD	7.4	110	70	20	+0.9	+6.3
Jan 18 19:53	3478	DD	6.4	53	25	35	+0.3	+2.4	Jan 05 04:15	128707	RD	6.9	70	40	302	+3.3	-4.9	Sep 15 22:58	2767	DD	6.3	111	39	47	+0.4	+2.4
Jan 19 20:48	128698	DD	7.0	64	20	349	-0.7	+5.7	Jan 07 05:25	110154	RD	7.4	48	32	248	+1.3	0.0	Sep 16 00:00	2771	DD	5.6	111	26	49	-0.1	+2.1
Jan 20 21:00	109653	DD	7.2	75	24	67	+0.9	+1.7	Jan 15 19:22	1408	DD	7.4	55	19	87	+1.3	+1.0	Sep 17 19:25	189680	DD	7.3	133	70	65	+2.5	+0.8
Jan 21 21:36	110154	DD	7.4	87	22	91	+1.2	+1.0	Jan 18 23:03	1773	DD	5.0	96	16	136	+0.4	-0.7	Sep 18 19:05	164528	DD	7.5	145	54	116	+2.2	-2.7
Jan 27 19:39	1097	DD	6.9	159	23	125	+2.1	-2.0	Jan 19 23:55	139236	DD	7.1	110	18	103	+0.6	+0.5	Sep 18 21:24	164567	DD	7.3	145	81	106	+3.7	-1.3
Jan 27 19:41	1099	DD	5.8	159	23	87	+1.5	-0.7	Jan 21 00:01	2020	DD	6.5	123	30	143	+0.9	-1.2	Sep 19 01:52	164637	DD	7.5	147	33	74	+0.7	+1.4
Jan 30 23:21	1533	RD	7.3	157	36	353	+1.1	-3.8	Jan 21 21:24	2130	DD	7.6	136	74	177	+0.4	-4.6	Sep 19 22:22	3304	DD	6.4	157	77	82	+3.0	+0.5
Jan 31 22:06	1651	RD	3.9	143	16	349	+0.8	-3.4	Jan 22 19:07	2259	DD	6.8	148	54	91	+1.9	-0.8	Sep 21 00:52	3428	DD	5.0	168	60	118	+5.2	-1.9
Feb 04 03:21	2035	RD	7.2	100	59	331	+0.9	-2.6	Jan 22 19:25	159520	DD	7.6	148	58	132	+1.1	-2.1	Sep 21 01:26	3428	RB	5.0	168	53	165	-1.8	+5.7
Feb 22 22:38	882	DD	5.0	114	21	42	+2.3	+2.8	Jan 22 20:54	159551	DD	7.2	149	76	129	+1.7	-1.9	Sep 21 03:24	3434	DD	7.5	169	28	355	-0.7	+4.2
Feb 23 20:17	1030	RB	3.1	126	37	257	+2.6	+0.4	Jan 23 20:07	2415	DD	7.3	162	57	112	+1.5	-1.5	Sep 23 20:10	202	RD	6.9	159	13	276	+0.7	-1.4
Feb 24 20:20	1180	DD	7.1	139	36	91	+2.4	-0.4	Jan 24 20:33	2562	DD	7.0	175	51	118	+1.1	-1.8	Sep 23 23:52	212	RD	7.2	158	53	221	+1.5	+1.6
Feb 24 21:39	79739	DD	7.1	139	38	161	+1.5	-3.1	Jan 26 00:17	187431	RD	7.3	171	86	332	+2.6	-5.9	Sep 24 01:34	219	DB	4.8	157	56	13	+0.8	+3.1
Feb 25 22:57	1334	DD	7.0	153	40	86	+2.6	+0.3	Jan 26 01:46	187465	RD	7.4	171	73	254	+2.3	+1.2	Sep 24 02:47	219	RD	4.8	157	49	269	+3.9	+0.8
Feb 27 03:36	1484	DD	3.5	169	16	94	+0.9	+0.7	Jan 26 03:14	2761	RD	6.6	170	54	273	+1.8	+0.7	Sep 28 03:48	709	DB	4.3	113	40	95	+3.1	-0.3
Mar 01 04:08	1739	RD	6.4	160	37	352	+0.1	-2.6	Jan 26 04:17	2767	RD	6.3	170	40	238	+0.6	+2.0	Oct 02 03:41	1270	RD	6.0	65	14	319	+1.7	-2.6
Mar 02 21:52	1965	RD	6.5	135	16	277	+0.4	-1.1	Jan 26 05:18	2771	RD	5.6	169	27	237	+0.1	+1.8	Oct 12 19:19	2703	DD	7.4	79	59	124	+2.6	-1.2
Mar 07 02:50	185512	RD	7.4	82	42	287	+1.0	-1.4	Jan 27 01:34	2907	RD	6.2	158	85	299	+3.2	-1.8	Oct 13 19:47	2861	DD	5.6	92	65	22	+0.6	+4.5
Mar 08 04:27	2689	RD	6.8	69	51	321	+0.7	-3.2	Jan 27 23:07	189680	RD	7.3	147	48	243	+1.8	+0.4	Oct 13 19:47	2864	DD	4.6	92	65	73	+2.0	+1.4
Mar 08 04:46	186977	RD	7.6	69	55	325	+0.8	-3.5	Jan 28 21:57	164528	RD	7.5	136	21	189	+2.0	+5.1	Oct 13 20:39	2861	RB	5.6	92	53	305	+2.9	-1.3
Mar 09 03:08	2836	RD	5.5	58	23	270	+0.5	-0.9	Jan 29 00:13	164567	RD	7.3	135	50	242	+1.9	+0.5	Oct 13 21:09	2864	RB	4.6	92	47	254	+1.2	+1.4
Mar 20 19:16	665	RB	5.7	69	26	324	+1.3	-2.5	Jan 29 00:19	3175	DB	4.7	135	51	113	+2.0	-2.4	Oct 14 23:12	3009	DD	7.4	105	32	66	+0.5	+1.6
Mar 20 20:47	76645	DD	7.1	70	11	60	+1.2	+1.8	Jan 29 01:25	3175	RD	4.7	135	66	207	+1.9	+3.1	Oct 15 23:46	3150	DD	6.6	116	34	27	-0.1	+2.7
Mar 22 21:07	977	DD	6.3	94	23	136	+0.9	-0.8	Jan 29 05:31	3191	RD	7.4	134	56	205	+0.5	+3.1	Oct 16 00:17	164449	DD	7.2	117	27	83	+0.7	+1.2
Mar 23 20:06	1117	DD	5.0	106	36	117	+2.2	-0.5	Jan 30 00:34	3304	RD	6.4	124	43	312	+2.0	-5.5	Oct 16 20:52	3265	DD	6.5	127	77	356	-0.5	+5.7
Mar 23 21:28	1117	RB	5.0	106	28	266	+2.0	+0.8	Jan 30 23:10	3413	RD	6.1	113	14	206	+0.6	+1.8	Oct 18 22:22	3506	DD	6.1	149	67	91	+3.5	+0.2
Mar 31 02:56	2056	RD	7.6	153	65	262	+2.8	+1.0	Jul 16 21:07	1856	DD	6.8	79	27	127	+0.8	-0.5	Oct 20 00:18	128823	DD	7.2	161	53	32	+1.2	+2.6
Apr 01 23:21	159763	DB	5.4	127	35	155	-0.1	-2.6	Jul 17 20:19	1976	DD	7.0	92	50	115	+1.7	-0.4	Oct 20 01:43	76	DD	5.9	161	37	88	+1.8	+1.1
Apr 01 23:21	2322	DB	4.1	127	35	155	-0.1	-2.6	Jul 17 20:54	1978	DD	6.6	93	43	115	+1.4	-0.2	Oct 22 21:01	394	RD	7.5	167	26	281	+2.0	-1.7
Apr 02 00:14	2322	RD	4.1	127	47	258	+1.9	-0.4	Jul 19 18:29	2213	RB	5.8	118	72	304	+1.8	-1.7	Oct 24 22:16	631	RD	5.6	144	18	266	+1.2	-0.8
Apr 02 00:14	159763	RD	5.4	127	47	258	+1.9	-0.4	Jul 19 18:39	2218	DD	5.5	118	74	103	+2.3	-0.9	Oct 24 23:04	634	RD	5.3	144	26	275	+2.0	-1.1
Apr 02 03:25	2338	RD	6.4	126	82	245	+3.5	+1.8	Jul 19 20:01	2218	RB	5.5	119	77	318	+1.8	-2.0	Oct 25 01:53	657	DB	5.3	143	40	89	+3.0	0.0
Apr 02 04:57	2343	RD	6.3	125	68	265	+2.4	+0.8	Jul 19 20:10	159358	DD	7.2	119	77	103	+2.5	-0.4	Oct 25 01:54	656	DB	4.2	143	40	68	+2.6	+0.7
Apr 04 00:51	186366	RD	7.3	101	32	315	+0.1	-2.3	Jul 19 22:50	2232	DD	7.2	120	45	133	+1.5	-1.0	Oct 25 03:24	657	RD	5.3	143	37	227	+2.3	+1.9
Apr 05 02:01	2790	RD	6.3	89	36	228	+1.9	+1.1	Jul 21 20:51	185466	DD	7.4	145	82	121	+2.2	-1.7	Oct 25 03:32	656	RD	4.2	143	36	249	+2.5	+1.3
Apr 05 04:57	2803	RD	7.6	88	74	293	+2.4	-1.7	Jul 21 21:26	2523	DD	4.8	145	86	142	+2.1	-3.0	Oct 27 01:30	932	RD	7.3	120	28	234	+1.5	+0.5
Apr 08 03:09	164637	RD	7.5	55	16	289	+0.1	-1.7	Jul 21 22:35	2523	RB	4.8	145	73	239	+2.5	+2.4	Oct 28 03:59	1089	RD	6.7	108	36	286	+2.7	-0.7
Apr 08 03:29	3191	RD	7.4	55	21	197	+1.5	+3.3	Jul 22 20:16	186864	DD	7.6	157	63	131	+1.4	-2.6	Oct 29 03:52	79980	RD	7.3	96	33	239	+2.3	+0.6
Apr 18 18:30	918	DD	7.0	63	27	30	+3.2	+4.0	Jul 22 21:27	186906	DD	7.6	157	78	81	+2.7	+0.2	Oct 30 04:03	1363	DB	5.2	83	30	116	+2.0	-1.5
Apr 19 18:20	78995	DD	7.4	75	34	156	+1.2	-2.8	Jul 23 18:58	2834	DD	5.0	168	34	71	+1.2	-0.2	Nov 09 19:43	2809	DD	4.9	60	38	69	+0.7	+1.5
Apr 22 23:27	1484	DD	3.5	115	22	183	-1.1	-3.7	Jul 23 19:10	2835	DD	7.3	169	37	43	+2.0	+1.5	Nov 09 20:47	2809	RB	4.9	61	24	263	+0.4	+1.1
Apr 22 23:56	1484	RB	3.5	116	16	236	+2.1	+3.4	Jul 23 20:05	2834	RB	5.0	169	49	299	+1.2	-2.1	Nov 11 19:39	3089	DD	5.3	84	61	88	+2.2	+0.8
Apr 25 01:31	1739	DD	6.4	144	26	44	+3.9	+9.0	Jul 25 21:51	3116	RD	6.6	166	48	237	+1.8	+0.7	Nov 11 20:50	3089	RB	5.3	85	45	216	+0.4	+2.6
Apr 25 02:05	119200	DD	7.1	144	19	164	+0.1	-2.0	Jul 26 21:40	3243	RD	7.3	154	34	264	+1.2	-0.8	Nov 12 21:53	164829	DD	7.1	97	41	61	+0.9	+1.8
Apr 26 00:22	1856	DD	6.8	158	52	166	+0.6	-2.6	Jul 27 02:34	3265	RD	6.5	153	74	264	+2.8	+0.7	Nov 12 21:53	3228	DD	7.2	97	41	61	+0.9	+1.8
Apr 26 02:10	1867	DD	7.5	158	32	96	+1.2	+0.6	Jul 29 03:47	3506	RD	6.1	130	67	246	+2.5	+1.4	Nov 14 00:43	3358	DD	6.9	109	12	120	+0.7	-0.2
Apr 26 18:35	1965	DD	6.5	169	20	97	+0.6	-1.1	Jul 30 02:19	66	RD	7.1	120	56	189	+0.6	+3.3	Nov 14 22:08	146786	DD	7.4	119	52	48	+1.3	+2.2
Apr 26 19:34	139528	DD	7.2	169	33	163	+0.2	-2.6	Aug 03 04:32	517	RD	6.1	74	36	257	+2.0	-0.2	Nov 14 22:49	3478	DD	6.4	119	43	24	+0.5	+2.8
Apr 28 00:45	2110	RD	6.3	173	74	298	+2.1	-1.0	Aug 04 03:12	651</																

LUNAR OCCULTATION TABLE

CANBERRA (35° 15' S, 149° 08'E)

AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B
Jan 02 02:29	1334	RD	7.0	150	33	283	+2.1	-0.2	Jun 01 00:41	3092	RD	6.2	116	37	297	+0.8	-2.5	Sep 12 22:22	2303	DD	4.8	73	15	123	+0.4	+0.1
Jan 05 00:42	1707	RD	5.3	110	16	6	+0.4	-4.7	Jun 02 02:25	164829	RD	7.1	104	46	280	+1.6	-1.7	Sep 12 22:22	2302	DD	2.6	73	15	124	+0.5	+0.1
Jan 10 03:12	159765	RD	7.4	45	13	313	-0.3	-1.8	Jun 02 02:25	3228	RD	7.2	104	46	280	+1.6	-1.7	Sep 12 23:13	2302	RB	2.6	74	5	254	-0.3	+1.4
Jan 20 20:43	109653	DD	7.2	75	28	79	+1.2	+1.6	Jun 03 05:59	3358	RD	6.9	92	67	280	+3.3	-0.8	Sep 14 23:49	186240	DD	7.3	99	23	98	+0.4	+0.9
Jan 21 21:24	110154	DD	7.4	87	24	108	+1.5	+0.7	Jun 05 04:24	128707	RD	6.9	70	36	268	+1.6	-1.2	Sep 14 23:58	186220	DD	7.2	99	21	14	-1.8	+5.4
Jan 22 22:22	384	DD	5.6	98	18	12	+1.0	+3.5	Jun 06 04:30	109653	RD	7.2	59	26	303	+2.3	-4.7	Sep 15 00:11	2610	DD	6.9	99	18	28	-0.9	+3.3
Jan 24 22:03	628	DD	4.9	122	28	2	+1.4	+5.0	Jun 07 05:20	110154	RD	7.4	48	24	228	+0.7	+0.4	Sep 15 20:00	187465	DD	7.4	110	77	56	+2.1	+2.1
Jan 24 22:29	628	RB	4.9	122	25	326	+1.9	-2.5	Jun 15 19:08	80882	DD	7.3	55	19	63	+2.2	+2.5	Sep 15 21:46	2761	DD	6.6	111	58	25	+0.5	+4.5
Jan 28 00:44	1117	DD	5.0	161	25	47	+2.7	+2.2	Jun 15 19:13	1408	DD	7.4	55	18	118	+0.8	+0.2	Sep 15 22:39	2767	DD	6.3	111	47	66	+1.0	+1.9
Jan 30 23:37	1533	RD	7.3	157	30	328	+1.3	-2.1	Jun 16 19:26	1533	DD	7.3	68	28	76	+2.2	+1.7	Sep 15 23:44	2771	DD	5.6	111	35	65	+0.4	+1.8
Jan 31 22:24	1651	RD	3.9	143	13	327	+0.7	-2.2	Jun 18 23:12	1773	DD	5.0	96	15	174	-0.1	-2.5	Sep 16 01:14	187660	DD	7.3	112	17	60	-0.2	+1.7
Feb 01 00:55	1665	RD	7.0	142	37	1	+0.3	-3.5	Jun 19 23:52	139236	DD	7.1	110	21	132	+0.6	-0.4	Sep 16 21:15	2907	DD	6.2	122	73	27	+1.2	+4.0
Feb 04 03:33	2035	RD	7.2	100	53	306	+1.4	-1.8	Jun 21 00:18	2020	DD	6.5	123	29	191	+0.3	-7.7	Sep 17 19:16	189680	DD	7.3	133	63	92	+2.1	-0.9
Feb 08 04:10	2567	RD	7.2	51	30	336	-0.5	-3.2	Jun 22 19:11	2259	DD	6.8	148	51	118	+1.1	-1.7	Sep 18 19:07	164516	DD	6.9	145	50	14	+1.6	+4.0
Feb 10 04:09	2875	RD	6.0	28	10	247	+0.1	-0.5	Jun 22 21:09	159551	DD	7.2	149	70	163	+0.7	-3.5	Sep 19 22:12	3304	DD	6.4	157	68	102	+3.2	-1.1
Feb 22 21:54	880	DD	6.8	113	23	32	+2.4	+2.9	Jun 23 20:19	2415	DD	7.3	162	55	140	+0.7	-2.5	Sep 21 00:40	3425	DD	4.4	168	59	346	-1.6	+5.7
Feb 22 22:15	882	DD	5.0	114	20	68	+1.9	+1.5	Jun 26 00:29	187431	RD	7.3	171	79	293	+2.3	-1.3	Sep 21 01:14	3425	RB	4.4	169	54	300	+4.4	-1.4
Feb 23 20:04	1030	RB	3.1	126	29	241	+2.1	+0.5	Jun 26 01:23	187465	RD	7.4	171	77	226	+2.0	+2.8	Sep 21 04:18	3446	DD	7.2	170	19	51	+0.3	+2.0
Feb 24 20:16	1180	DD	7.1	139	27	106	+2.1	-0.9	Jun 26 01:38	2756	RD	7.5	171	74	333	+3.1	-5.8	Sep 23 23:35	212	RD	7.2	158	42	206	+0.9	+1.7
Feb 25 22:49	1334	DD	7.0	153	33	107	+2.0	-0.4	Jun 26 02:59	2761	RD	6.6	170	60	252	+1.6	+1.5	Sep 24 01:10	219	DB	4.8	157	49	23	+1.0	+2.2
Feb 27 03:31	1484	DD	3.5	169	15	125	+0.5	0.0	Jun 26 03:55	2767	RD	6.3	170	49	217	+0.5	+3.1	Sep 24 02:29	219	RD	4.8	157	46	259	+2.5	+1.0
Mar 01 04:17	1739	RD	6.4	160	34	316	+0.9	-0.7	Jun 26 05:00	2771	RD	5.6	169	36	219	0.0	+2.7	Sep 28 03:42	709	DB	4.3	112	31	108	+3.0	-1.0
Mar 02 01:26	1854	RD	6.8	147	52	336	+0.9	-2.2	Jun 27 01:29	2907	DD	6.2	158	78	270	+2.4	-0.1	Oct 12 13:36	2672	DD	2.8	78	44	133	+0.4	-2.5
Mar 02 21:58	1965	RD	6.5	135	14	257	+0.5	-0.9	Jun 27 22:50	189680	RD	7.3	147	41	204	+2.0	+3.0	Oct 12 14:40	2672	RB	2.8	78	57	249	+2.0	0.0
Mar 05 03:31	2246	RD	7.3	106	63	350	+0.2	-3.9	Jun 28 22:09	164516	RD	6.9	136	21	293	+0.2	-2.1	Oct 12 22:58	2719	DD	5.8	81	19	54	-0.3	+1.9
Mar 07 02:54	185512	RD	7.4	82	40	259	+1.3	-0.8	Jun 28 23:57	164567	RD	7.3	135	43	209	+1.6	+2.0	Oct 13 19:16	2861	DD	5.6	92	73	50	+1.7	+2.4
Mar 08 03:51	2692	DB	5.5	69	41	68	+1.5	-0.3	Jun 29 05:02	3191	RD	7.4	134	62	188	0.0	+4.2	Oct 13 19:32	2864	DD	4.6	92	70	94	+2.3	+0.4
Mar 08 04:41	2689	RD	6.8	69	51	289	+1.2	-1.7	Jun 30 00:47	3304	RD	6.4	123	42	273	+1.5	-1.4	Oct 13 20:32	2861	RB	5.6	92	58	282	+2.0	+0.4
Mar 08 04:56	2692	RD	5.5	69	54	314	+0.9	-2.8	Jul 15 20:29	1739	DD	6.4	66	22	88	+1.1	+1.3	Oct 13 20:51	2864	RB	4.6	92	54	237	+1.1	+2.1
Mar 09 03:11	2836	RD	5.5	58	23	241	+0.7	-0.3	Jul 16 21:13	1856	DD	6.8	79	27	161	+0.4	-1.7	Oct 14 22:58	3009	DD	7.4	105	39	78	+0.9	+1.5
Mar 20 19:15	665	RB	5.7	69	22	296	+1.7	+0.2	Jul 17 18:11	139528	DD	7.2	92	61	98	+2.4	-0.3	Oct 15 23:26	3150	DD	6.6	116	41	39	+0.4	+2.4
Mar 20 20:31	76645	DD	7.1	70	12	82	+1.2	+1.4	Jul 17 20:20	1976	DD	7.0	92	49	147	+1.1	-1.5	Oct 16 00:04	164449	DD	7.2	117	34	95	+1.0	+1.1
Mar 23 20:05	1117	DD	5.0	106	29	139	+1.8	-1.2	Jul 17 20:55	1978	DD	6.6	93	43	146	+1.0	-1.3	Oct 16 20:16	3265	DD	6.5	127	70	21	+1.2	+3.2
Mar 23 21:10	1117	RB	5.0	106	25	240	+2.5	+1.7	Jul 18 21:06	2097	DD	6.8	106	53	89	+2.0	+0.9	Oct 17 02:08	3284	DD	7.0	129	16	113	+0.6	+0.6
Mar 25 23:27	1408	DD	7.4	134	28	59	+2.9	+2.4	Jul 19 00:27	2110	DD	6.3	107	15	90	+0.3	+1.2	Oct 18 00:36	3392	DD	7.3	139	40	358	-0.6	+3.8
Mar 26 21:29	1533	DD	7.3	147	38	68	+2.8	+0.5	Jul 19 18:31	2213	RB	5.8	118	65	275	+2.1	-0.8	Oct 18 22:11	3506	DD	6.1	149	61	108	+4.1	-1.3
Mar 27 19:53	1651	DD	3.9	160	25	58	+1.6	+0.1	Jul 19 18:43	2218	DD	5.5	118	67	132	+1.4	-2.0	Oct 19 23:55	128823	DD	7.2	161	52	40	+1.4	+2.1
Mar 27 20:29	1651	RB	3.9	160	31	356	+0.6	-3.2	Jul 19 20:03	2218	RB	5.5	119	71	287	+2.1	-0.7	Oct 20 01:27	76	DD	5.9	161	39	99	+2.2	+0.9
Mar 30 21:08	2035	RD	7.2	155	22	347	-0.1	-2.6	Jul 19 20:10	159358	DD	7.2	119	71	133	+1.7	-1.7	Oct 24 22:17	631	RD	5.6	144	11	249	+0.7	-0.5
Mar 30 23:18	2047	RD	6.6	154	47	354	0.0	-3.2	Jul 19 23:01	2232	DD	7.2	120	45	173	+1.4	-4.8	Oct 24 23:05	634	RD	5.3	144	18	259	+1.3	-0.7
Apr 01 04:11	2193	RD	6.1	139	63	323	+1.5	-1.8	Jul 21 21:06	185466	DD	7.4	145	77	159	+1.2	-4.6	Oct 25 01:42	656	DB	4.2	143	32	79	+2.4	+0.1
Apr 02 04:28	2343	RD	6.3	125	72	219	+3.9	+6.9	Jul 23 19:01	2834	DD	5.0	169	33	100	+0.6	-1.4	Oct 25 03:01	657	RD	5.3	143	32	213	+1.8	+1.9
Apr 02 05:20	159860	RD	7.4	125	64	283	+2.0	0.0	Jul 23 19:04	2835	DD	7.3	169	33	78	+0.9	-0.8	Oct 25 03:13	656	RD	4.2	143	31	236	+2.2	+1.3
Apr 02 02:15	185012	RD	7.0	115	10	246	+0.2	-0.5	Jul 23 20:12	2834	RB	5.0	169	47	269	+1.3	-1.0	Oct 27 01:22	932	RD	7.3	120	19	220	+0.8	+0.6
Apr 04 01:04	186366	RD	7.3	101	33	288	+0.5	-1.6	Jul 25 21:32	3116	RD	6.6	166	40	197	+1.8	+3.6	Oct 28 03:54	1089	RD	6.7	108	27	271	+2.3	-0.4
Apr 05 03:24	187779	RD	7.4	89	50	336	+0.1	-5.2	Jul 26 05:36	3150	RD	6.6	163	32	206	-0.2	+2.7	Oct 29 03:38	79980	RD	7.3	96	23	217	+1.4	+1.3
Apr 25 01:07	1739	DD	6.4	144	30	96	+1.3	+0.8	Jul 26 21:38	3243	RD	7.3	154	30	235	+1.0	+0.2	Nov 09 20:35	2809	RB	4.9	61	32	249	+0.4	+1.6
Apr 26 18:44	1965	DD	6.5	169	18	115	+0.4	-1.6	Jul 27 02:17	3265	RD	6.5	153	70	248	+2.2	+1.1	Nov 11 20:26	3089	RB	5.3	85	53	201	+0.2	+3.3
Apr 27 04:44	2008	DD	6.6	173	17	149	+0.5	-1.0	Jul 29 03:28	3506	RD	6.1	130	61	235	+1.9	+1.5	Nov 12 21:36	164829	DD	7.1	97	47	71	+1.2	+1.7
Apr 28 00:40	2110	RD	6.3	173	68	266	+2.5	+0.3	Aug 03 04:26	517	RD	6.1	74	27	243	+1.3	0.0	Nov 12 21:36	3228	DD	7.2	97	47	71	+1.2	+1.7
Apr 29 02:42	2259	RD	6.8	159	66	338	+1.3	-3.0	Aug 04 04:52	665	DB	5.7	63	20	78	+1.4	-0.6	Nov 14 21:47	146786	DD	7.4	119	54	56	+1.6	+1.9
Apr 29 04:34	159551	RD	7.2	158	46	268	+1.4	+1.1	Aug 04 05:05	76609	RD	7.4</														

LUNAR OCCULTATION TABLE

MELBOURNE (37° 50' S, 145° 00'E)

AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B
Jan 02 02:20	1334	RD	7.0	150	30	274	+2.1	-0.2	May 30 03:16	2834	DB	5.0	139	77	73	+2.2	+0.8	Sep 14 23:45	186240	DD	7.3	99	27	100	+0.6	+0.9
Jan 05 00:50	1707	RD	5.3	110	14	354	+0.6	-3.2	May 30 04:42	2834	RD	5.0	139	67	271	+2.0	+0.6	Sep 14 23:51	186220	DD	7.2	99	26	19	-1.2	+4.7
Jan 10 03:18	159765	RD	7.4	45	11	304	-0.2	-1.7	May 30 04:43	2835	RD	7.3	139	67	292	+2.3	-0.5	Sep 15 00:06	2610	DD	6.9	99	23	31	-0.7	+3.3
Jan 17 21:02	3356	DD	5.8	43	12	60	0.0	+1.8	Jun 01 00:43	3092	RD	6.2	116	34	284	+0.7	-1.8	Sep 15 19:46	187465	DD	7.4	110	77	65	+2.2	+1.3
Jan 21 21:15	110154	DD	7.4	87	27	110	+1.8	+0.7	Jun 02 02:22	164829	RD	7.1	104	42	270	+1.4	-1.2	Sep 15 21:32	2761	DD	6.6	111	63	32	+1.0	+4.0
Jan 22 22:10	384	DD	5.6	98	21	18	+1.0	+3.0	Jun 02 02:22	3228	RD	7.2	104	42	270	+1.4	-1.2	Sep 15 22:30	2767	DD	6.3	111	52	68	+1.2	+1.8
Jan 24 21:47	628	DD	4.9	122	28	9	+1.3	+3.3	Jun 03 05:48	3358	RD	6.9	92	63	279	+2.9	-0.9	Sep 15 23:37	2771	DD	5.6	111	39	67	+0.6	+1.9
Jan 24 22:25	628	RB	4.9	122	25	316	+2.1	-1.0	Jun 05 04:20	128707	RD	6.9	70	31	263	+1.3	-1.0	Sep 16 01:10	187660	DD	7.3	112	22	60	-0.1	+1.8
Jan 28 00:29	1117	DD	5.0	161	25	60	+2.3	+1.3	Jun 05 06:21	49	DB	6.1	69	49	0	+0.1	+3.7	Sep 16 02:14	2790	DD	6.3	113	10	82	-0.2	+1.2
Jan 30 23:36	1533	RD	7.3	157	26	320	+1.3	-1.9	Jun 06 04:33	109653	RD	7.2	59	23	293	+1.5	-3.1	Sep 16 21:00	2907	DD	6.2	122	75	34	+1.6	+3.3
Jan 31 22:26	1651	RD	3.9	143	10	321	+0.6	-2.1	Jun 07 05:16	110154	RD	7.4	48	20	224	+0.5	+0.4	Sep 17 19:11	189680	DD	7.3	133	58	102	+1.9	-1.6
Feb 01 01:00	1665	RD	7.0	142	34	347	+0.8	-2.6	Jun 08 06:15	384	RD	5.6	36	19	271	+1.3	-1.4	Sep 19 22:02	3304	DD	6.4	157	64	105	+3.0	-1.6
Feb 04 03:31	2035	RD	7.2	100	49	294	+1.4	-1.5	Jun 15 18:55	80882	DD	7.3	55	21	82	+1.7	+1.3	Sep 21 00:32	3425	DD	4.4	168	59	341	-2.5	+7.0
Feb 08 04:18	2567	RD	7.2	51	29	320	-0.1	-2.5	Jun 15 19:10	1408	DD	7.4	55	19	131	+0.7	-0.2	Sep 21 00:58	3425	RB	4.4	169	56	305	+5.5	-2.9
Feb 22 21:38	880	DD	6.8	113	23	42	+2.2	+2.0	Jun 16 19:15	1533	DD	7.3	68	29	93	+1.8	+0.8	Sep 21 04:11	3446	DD	7.2	170	24	51	+0.4	+2.0
Feb 22 22:04	882	DD	5.0	114	21	75	+1.9	+1.2	Jun 19 23:51	139236	DD	7.1	110	24	144	+0.6	-0.8	Sep 23 23:28	212	RD	7.2	158	37	206	+0.7	+1.5
Feb 23 19:54	1030	RB	3.1	126	26	238	+1.8	+0.4	Jun 22 19:12	2259	DD	6.8	148	47	130	+0.7	-2.0	Sep 24 01:01	219	DB	4.8	157	45	21	+0.9	+2.0
Feb 23 22:18	78778	DD	6.8	126	24	37	+2.6	+2.4	Jun 23 20:24	2415	DD	7.3	162	52	156	+0.2	-3.1	Sep 24 02:17	219	RD	4.8	157	45	262	+2.5	+0.7
Feb 23 23:58	78827	DD	7.4	127	14	63	+1.7	+1.8	Jun 26 00:23	187431	RD	7.3	171	75	283	+2.1	-0.9	Sep 28 03:33	709	DB	4.3	112	28	108	+2.8	-1.2
Feb 24 20:10	1180	DD	7.1	139	23	110	+1.9	-1.1	Jun 26 02:48	2761	RD	6.6	170	64	248	+1.6	+1.7	Sep 28 04:43	709	RD	4.3	112	29	210	+1.5	+1.7
Feb 25 22:42	1334	DD	7.0	153	30	116	+1.8	-0.7	Jun 26 03:45	2767	RD	6.3	170	54	213	+0.6	+3.6	Sep 28 04:43	76720	RD	7.0	112	29	210	+1.5	+1.7
Feb 27 03:30	1484	DD	3.5	169	17	139	+0.4	-0.4	Jun 26 04:52	2771	RD	5.6	169	41	217	+0.1	+3.0	Oct 12 13:43	2672	DD	2.8	78	42	150	-0.1	-3.4
Mar 01 01:14	1739	RD	6.4	160	35	303	+1.1	-0.2	Jun 26 06:26	187660	RD	7.3	169	23	226	+0.3	+2.2	Oct 12 14:31	2672	RB	2.8	78	51	232	+2.2	+0.8
Mar 02 01:27	1854	RD	6.8	147	49	323	+1.1	-1.8	Jun 27 01:20	2907	RD	6.2	158	74	263	+2.2	+0.1	Oct 12 22:54	2719	DD	5.8	81	24	55	-0.1	+2.0
Mar 02 21:58	1965	RD	6.5	135	10	248	+0.4	-0.7	Jun 28 22:13	164516	RD	6.9	136	19	280	+0.2	-1.6	Oct 13 19:22	2864	DD	4.6	92	73	99	+2.3	0.0
Mar 05 03:37	2246	RD	7.3	106	60	332	+0.8	-2.8	Jun 28 23:44	164567	RD	7.3	135	37	191	+1.7	+4.2	Oct 13 20:23	2861	RB	5.6	92	62	279	+2.0	+0.4
Mar 07 02:51	185512	RD	7.4	82	36	244	+1.3	-0.3	Jun 29 04:51	3191	RD	7.4	134	65	188	+0.2	+4.3	Oct 13 20:41	2864	RB	4.6	92	59	235	+1.2	+2.2
Mar 08 03:48	2692	DB	5.5	69	37	82	+1.0	-1.0	Jun 30 00:45	3304	RD	6.4	123	37	264	+1.2	-1.0	Oct 14 22:50	3009	DD	7.4	105	44	78	+1.0	+1.5
Mar 08 04:40	2689	RD	6.8	69	47	276	+1.2	-1.3	Jul 01 01:54	3428	DB	5.0	112	39	349	0.0	+8.0	Oct 15 23:18	3150	DD	6.6	116	46	38	+0.5	+2.5
Mar 08 04:58	2692	RD	5.5	69	50	299	+1.0	-2.1	Jul 01 02:18	3428	RD	5.0	112	43	314	+3.3	-8.0	Oct 15 23:57	164449	DD	7.2	117	39	94	+1.2	+1.2
Mar 09 03:08	2836	RD	5.5	58	20	225	+0.9	+0.3	Jul 14 20:31	1621	DD	7.2	52	10	106	+0.5	+0.7	Oct 16 20:04	3265	DD	6.5	127	65	24	+1.3	+2.8
Mar 20 20:22	76645	DD	7.1	70	14	89	+1.3	+1.2	Jul 15 20:22	1739	DD	6.4	66	25	103	+1.0	+0.7	Oct 17 02:03	3284	DD	7.0	129	21	114	+0.9	+0.7
Mar 23 20:01	1117	DD	5.0	106	27	149	+1.7	-1.7	Jul 16 21:17	1856	DD	6.8	80	28	180	0.0	-3.4	Oct 18 00:29	3392	DD	7.3	139	44	355	-0.7	+4.1
Mar 23 20:54	1117	RB	5.0	106	25	227	+2.7	+2.0	Jul 17 20:21	1976	DD	7.0	93	50	163	+0.8	-2.3	Oct 18 21:58	3506	DD	6.1	149	58	106	+3.6	-1.4
Mar 25 23:13	1408	DD	7.4	134	28	78	+2.2	+1.1	Jul 17 20:56	1978	DD	6.6	93	44	162	+0.8	-2.1	Oct 19 23:44	128823	DD	7.2	161	52	37	+1.3	+2.0
Mar 26 21:18	1533	DD	7.3	147	34	80	+2.2	-0.3	Jul 18 20:57	2097	DD	6.8	106	56	103	+1.9	+0.1	Oct 20 01:15	76	DD	5.9	161	42	97	+2.4	+0.9
Mar 27 19:48	1651	DD	3.9	160	20	68	+1.2	-0.6	Jul 19 00:23	2110	DD	6.3	107	20	97	+0.5	+1.0	Oct 24 23:02	634	RD	5.3	144	13	259	+1.1	-0.8
Mar 27 20:33	1651	RB	3.9	160	27	344	+0.8	-2.5	Jul 19 18:23	2213	RB	5.8	118	60	259	+2.3	-0.3	Oct 25 01:33	656	DB	4.2	143	28	78	+2.1	-0.1
Mar 30 21:15	2035	RD	7.2	155	19	336	0.0	-2.3	Jul 19 18:44	2218	DD	5.5	118	62	146	+1.0	-2.4	Oct 25 02:49	657	RD	5.3	143	30	212	+1.6	+1.6
Mar 30 22:56	2043	RD	6.5	154	39	351	0.0	-2.9	Jul 19 19:55	2218	RB	5.5	119	69	273	+2.3	-0.2	Oct 25 03:02	656	RD	4.2	143	30	235	+2.0	+1.0
Mar 30 23:24	2047	RD	6.6	154	44	339	+0.4	-2.5	Jul 19 20:09	159358	DD	7.2	119	69	148	+1.3	-2.4	Oct 27 01:17	932	RD	7.3	120	14	220	+0.6	+0.4
Apr 01 03:41	159188	RD	7.4	139	66	346	+0.9	-3.3	Jul 22 03:56	185674	DD	7.3	147	16	74	-0.1	+1.5	Oct 28 03:46	1089	RD	6.7	108	23	268	+2.1	-0.6
Apr 01 04:08	2193	RD	6.1	139	64	310	+1.6	-1.2	Jul 23 19:03	2834	DD	5.0	169	30	113	+0.3	-1.8	Oct 28 04:16	79164	RD	7.4	108	25	306	+2.3	-1.3
Apr 02 05:11	159860	RD	7.4	125	66	272	+2.1	+0.4	Jul 23 19:04	2835	DD	7.3	169	30	91	+0.6	-1.2	Oct 29 03:29	79980	RD	7.3	96	18	211	+0.9	+1.5
Apr 04 01:06	186366	RD	7.3	101	31	276	+0.5	-1.3	Jul 26 05:30	3150	RD	6.6	163	36	207	0.0	+2.7	Oct 30 04:07	1363	DB	5.2	83	18	136	+1.6	-2.0
Apr 05 03:32	187779	RD	7.4	88	48	316	+0.7	-3.1	Jul 26 21:34	3243	RD	7.3	154	26	223	+0.9	+0.6	Nov 06 17:19	2302	DD	2.6	19	36	31	+0.1	+6.8
Apr 05 05:33	2811	DB	6.2	88	70	28	+2.7	+4.6	Jul 27 02:06	3265	RD	6.5	153	68	247	+2.1	+1.0	Nov 06 17:40	2302	RB	2.6	20	32	354	+1.8	-5.1
Apr 25 01:00	1739	DD	6.4	144	32	111	+1.2	+0.3	Jul 29 03:16	3506	RD	6.1	130	58	235	+1.9	+1.2	Nov 09 20:29	2809	RB	4.9	61	37	248	+0.5	+1.7
Apr 26 18:47	1965	DD	6.5	169	15	122	+0.2	-1.7	Aug 03 04:22	517	RD	6.1	74	22	243	+1.1	-0.2	Nov 11 20:17	3089	RB	5.3	85	57	202	+0.4	+3.3
Apr 27 04:45	2008	DD	6.6	173	20	162	+0.5	-1.7	Aug 04 05:01	76609	RD	7.4	63	18	239	+0.9	-0.2	Nov 12 21:26	164829	DD	7.1	97	51	70	+1.4	+1.7
Apr 28 00:26	2110	RD	6.3	173	65	246	+3.2	+1.4	Aug 04 06:03	665	RD	5.7	62	25	231	+1.2	+0.3	Nov 12 21:26	3228	DD	7.2	97	51	70	+1.4	+1.7
Apr 29 02:42	2259	RD	6.8	159	66	323	+1.5	-1.9	Aug 13 21:16	1950	DD	5.7	6													

LUNAR OCCULTATION TABLE

SYDNEY (33° 54' S, 151° 15'E)

AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD	Mag	Elg	Alt	PA	A	B
Jan 02 02:32	1334	RD	7.0	150	34	288	+2.0	-0.3	May 30 04:55	2835	RD	7.3	139	62	300	+2.5	-0.8	Sep 15 00:02	186220	DD	7.2	99	18	10	-2.3	+6.3
Jan 04 23:53	1701	RD	4.8	110	10	298	+0.5	-1.7	May 30 04:57	2834	RD	5.0	139	61	277	+2.0	+0.5	Sep 15 00:13	2610	DD	6.9	99	16	26	-1.1	+3.4
Jan 19 20:23	128698	DD	7.0	64	25	11	+0.2	+3.2	Jun 01 00:39	3092	RD	6.2	116	38	305	+0.8	-3.1	Sep 15 20:07	187465	DD	7.4	110	75	51	+2.0	+2.5
Jan 20 20:47	109653	DD	7.2	75	26	78	+1.1	+1.6	Jun 02 02:26	164829	RD	7.1	104	48	285	+1.8	-2.0	Sep 15 21:53	2761	DD	6.6	111	55	22	+0.2	+4.9
Jan 22 22:29	384	DD	5.6	98	16	7	+1.0	+3.9	Jun 02 02:26	3228	RD	7.2	104	48	285	+1.8	-2.0	Sep 15 22:43	2767	DD	6.3	111	45	64	+0.9	+1.9
Jan 24 22:15	628	DD	4.9	122	27	354	+1.5	+9.7	Jun 05 04:26	128707	RD	6.9	70	38	271	+1.9	-1.3	Sep 15 23:47	2771	DD	5.6	111	32	64	+0.3	+1.8
Jan 24 22:27	628	RB	4.9	122	25	336	+1.7	-7.1	Jun 06 04:28	109653	RD	7.2	59	28	310	+3.2	-7.1	Sep 16 01:16	187660	DD	7.3	112	15	59	-0.3	+1.7
Jan 28 00:54	1117	DD	5.0	161	24	37	+3.2	+3.4	Jun 08 05:22	384	DB	5.6	36	16	19	0.0	+1.6	Sep 16 21:23	2907	DD	6.2	122	71	24	+1.0	+4.3
Jan 30 23:36	1533	RD	7.3	157	32	332	+1.3	-2.3	Jun 15 19:18	80882	DD	7.3	55	17	47	+3.3	+4.8	Sep 17 19:20	189680	DD	7.3	133	66	87	+2.3	-0.5
Jan 31 22:22	1651	RD	3.9	143	15	330	+0.8	-2.4	Jun 16 19:34	1533	DD	7.3	68	26	64	+2.6	+2.7	Sep 18 19:17	164516	DD	6.9	145	54	4	+1.5	+6.4
Feb 04 03:33	2035	RD	7.2	100	56	312	+1.3	-1.9	Jun 18 23:10	1773	DD	5.0	96	14	165	+0.1	-1.8	Sep 19 22:17	3304	DD	6.4	157	70	101	+3.3	-0.9
Feb 08 04:03	2567	RD	7.2	51	30	346	-0.9	-4.0	Jun 19 23:53	139236	DD	7.1	110	19	126	+0.5	-0.2	Sep 21 00:45	3425	DD	4.4	168	58	348	-1.3	+5.3
Feb 10 04:00	2872	RD	6.3	28	10	253	+0.1	-0.6	Jun 21 00:12	2020	DD	6.5	123	29	176	+0.6	-3.6	Sep 21 01:21	3425	RB	4.4	169	52	298	+4.0	-1.0
Feb 10 04:08	2875	RD	6.0	28	11	254	+0.1	-0.6	Jun 22 19:12	2259	DD	6.8	148	53	111	+1.3	-1.5	Sep 21 04:21	3446	DD	7.2	170	17	50	+0.2	+2.0
Feb 22 22:04	880	DD	6.8	113	22	23	+2.8	+4.1	Jun 22 21:06	159551	DD	7.2	149	72	153	+1.1	-2.9	Sep 23 23:39	212	RD	7.2	158	45	206	+0.9	+1.8
Feb 22 22:21	882	DD	5.0	114	20	63	+1.9	+1.7	Jun 23 20:17	2415	DD	7.3	162	57	133	+1.0	-2.2	Sep 24 01:16	219	DB	4.8	157	50	24	+1.1	+2.2
Feb 23 18:50	1030	DD	3.1	125	27	108	+2.2	-1.1	Jun 26 00:32	187431	RD	7.3	171	81	299	+2.4	-1.6	Sep 24 02:36	219	RD	4.8	157	46	258	+2.4	+1.1
Feb 23 20:09	1030	RB	3.1	126	31	243	+2.2	+0.6	Jun 26 01:30	187465	RD	7.4	171	75	231	+2.0	+2.5	Sep 28 03:47	709	DB	4.3	112	33	108	+3.1	-0.9
Feb 24 18:45	1170	RB	3.6	138	21	227	+1.1	+0.5	Jun 26 03:04	2761	RD	6.6	170	57	255	+1.5	+1.5	Sep 28 05:01	709	RD	4.3	112	32	212	+1.9	+2.1
Feb 24 20:19	1180	DD	7.1	139	30	104	+2.1	-0.8	Jun 26 04:01	2767	RD	6.3	170	46	219	+0.4	+3.0	Oct 02 03:52	1270	RD	6.0	65	10	302	+1.4	-1.9
Feb 25 22:53	1334	DD	7.0	153	34	102	+2.1	-0.2	Jun 26 05:04	2771	RD	5.6	169	33	220	-0.1	+2.6	Oct 12 13:34	2672	DD	2.8	77	45	125	+0.7	-2.2
Feb 27 03:32	1484	DD	3.5	169	15	118	+0.6	+0.2	Jun 27 01:34	2907	RD	6.2	158	40	274	+2.5	-0.2	Oct 12 23:00	2719	DD	5.8	81	17	53	-0.3	+1.9
Mar 01 04:18	1739	RD	6.4	160	33	324	+0.7	-1.0	Jun 27 22:57	189680	RD	7.3	147	44	214	+1.9	-0.9	Oct 13 19:23	2861	DD	5.6	92	70	47	+1.6	+2.6
Mar 02 01:24	1854	RD	6.8	147	54	344	+0.7	-2.5	Jun 28 22:06	164516	RD	6.9	136	22	301	+0.1	-2.5	Oct 13 19:37	2864	DD	4.6	92	68	91	+2.2	+0.6
Mar 02 21:57	1965	RD	6.5	135	15	262	+0.5	-0.9	Jun 29 00:03	164567	RD	7.3	135	46	216	+1.6	+1.6	Oct 13 20:37	2861	RB	5.6	92	55	284	+2.0	+0.3
Mar 05 03:24	2246	RD	7.3	106	64	4	-0.8	-5.5	Jun 29 05:08	3191	RD	7.4	134	60	188	-0.1	+4.1	Oct 13 20:56	2864	RB	4.6	92	52	238	+1.0	+2.1
Mar 07 02:56	185512	RD	7.4	82	42	267	+1.2	-1.0	Jun 30 00:49	3304	RD	6.4	123	44	278	+1.7	-1.6	Oct 14 23:01	3009	DD	7.4	105	36	78	+0.8	+1.4
Mar 08 03:55	2692	DB	5.5	69	43	59	+1.8	+0.2	Jul 15 20:33	1739	DD	6.4	66	20	79	+1.1	+1.7	Oct 15 23:30	3150	DD	6.6	116	39	39	+0.3	+2.4
Mar 08 04:41	2689	RD	6.8	69	53	296	+1.2	-2.0	Jul 16 21:11	1856	DD	6.8	79	26	153	+0.5	-1.3	Oct 16 00:08	164449	DD	7.2	117	31	95	+1.0	+1.1
Mar 08 04:53	2692	RD	5.5	69	55	322	+0.8	-3.4	Jul 17 18:16	139528	DD	7.2	92	62	89	+2.7	+0.2	Oct 16 20:23	3265	DD	6.5	127	72	20	+1.1	+3.4
Mar 09 03:12	2836	RD	5.5	58	24	249	+0.7	-0.5	Jul 17 20:21	1976	DD	7.0	92	48	139	+1.2	-1.2	Oct 17 02:10	3284	DD	7.0	129	14	113	+0.5	+0.6
Mar 20 19:19	665	RB	5.7	69	22	300	+1.6	0.0	Jul 17 20:56	1978	DD	6.6	93	42	139	+1.1	-1.0	Oct 18 00:40	3392	DD	7.3	139	38	359	-0.5	+3.8
Mar 20 20:35	76645	DD	7.1	70	11	77	+1.1	+1.5	Jul 18 21:12	2097	DD	6.8	106	52	81	+2.0	+1.4	Oct 18 22:18	3506	DD	6.1	149	62	109	+4.3	-1.3
Mar 22 21:18	977	DD	6.3	94	18	167	-0.8	-3.8	Jul 19 00:29	2110	DD	6.3	107	13	86	+0.2	+1.3	Oct 20 00:01	128823	DD	7.2	161	51	41	+1.4	+2.2
Mar 23 20:07	1117	DD	5.0	106	30	134	+1.8	-0.9	Jul 19 18:34	2213	RB	5.8	118	68	283	+2.1	-1.0	Oct 20 01:33	76	DD	5.9	161	37	100	+2.1	+0.8
Mar 23 21:17	1117	RB	5.0	106	25	247	+2.3	+1.5	Jul 19 18:43	2218	DD	5.5	118	69	124	+1.6	-1.7	Oct 24 22:18	631	RD	5.6	144	13	250	+0.8	-0.5
Mar 26 21:36	1533	DD	7.3	147	40	58	+3.5	+1.4	Jul 19 20:06	2218	RB	5.5	119	72	294	+2.1	-0.9	Oct 24 23:07	634	RD	5.3	144	20	260	+1.4	-0.7
Mar 27 19:57	1651	DD	3.9	160	28	51	+2.1	+0.9	Jul 19 20:12	159358	DD	7.2	119	72	126	+1.9	-1.4	Oct 25 01:47	656	DB	4.2	143	34	79	+2.5	+0.2
Mar 27 20:25	1651	RB	3.9	160	32	5	+0.2	-4.0	Jul 19 22:59	2232	DD	7.2	120	44	163	+1.4	-3.1	Oct 25 03:08	657	RD	5.3	143	32	214	+1.9	+2.1
Mar 30 21:04	2035	RD	7.2	155	23	354	-0.3	-3.0	Jul 21 21:03	185466	DD	7.4	145	78	149	+1.6	-3.5	Oct 25 03:20	656	RD	4.2	143	31	237	+2.2	+1.4
Apr 01 04:11	2193	RD	6.1	139	63	331	+1.4	-2.3	Jul 23 19:01	2834	DD	5.0	169	34	93	+0.8	-1.2	Oct 27 01:24	932	RD	7.3	120	21	220	+0.9	+0.7
Apr 01 23:43	159763	DB	5.4	127	38	185	-1.6	-4.9	Jul 23 19:05	2835	DD	7.3	169	35	71	+1.1	-0.4	Oct 28 03:58	1089	RD	6.7	108	29	273	+2.4	-0.4
Apr 01 23:43	2322	DB	4.1	127	38	185	-1.6	-5.0	Jul 23 20:13	2834	RB	5.0	169	49	275	+1.4	-1.2	Oct 29 03:43	79980	RD	7.3	96	25	220	+1.7	+1.2
Apr 02 00:07	2322	RD	4.1	127	43	227	+3.3	+1.9	Jul 25 21:39	3116	RD	6.6	166	44	208	+1.7	+2.4	Nov 09 19:32	2809	DD	4.9	60	43	84	+1.0	+1.2
Apr 02 00:08	159763	RD	5.4	127	43	227	+3.2	+1.8	Jul 26 05:39	3150	RD	6.6	163	29	206	-0.2	+2.6	Nov 09 20:38	2809	RB	4.9	61	29	249	+0.3	+1.6
Apr 02 04:41	2343	RD	6.3	125	70	234	+2.9	+3.4	Jul 26 21:41	3243	RD	7.3	154	32	241	+1.1	0.0	Nov 11 19:32	3089	DD	5.3	84	63	105	+2.7	0.0
Apr 02 22:15	185012	RD	7.0	115	12	252	+0.2	-0.6	Jul 27 02:23	3265	RD	6.5	153	71	249	+2.2	+1.2	Nov 11 20:31	3089	RB	5.3	85	51	201	+0.1	+3.3
Apr 04 01:03	186366	RD	7.3	101	34	294	+0.5	-1.7	Jul 29 03:34	3506	RD	6.1	130	62	234	+1.9	+1.6	Nov 12 21:40	164829	DD	7.1	97	45	72	+1.2	+1.6
Apr 25 01:11	1739	DD	6.4	144	28	88	+1.4	+1.2	Aug 03 04:29	517	RD	6.1	74	29	243	+1.4	0.0	Nov 12 21:41	3228	DD	7.2	97	45	72	+1.2	+1.6
Apr 26 18:43	1965	DD	6.5	169	20	111	+0.5	-1.5	Aug 04 04:55	665	DB	5.7	63	23	78	+1.5	-0.6	Nov 14 21:53	146786	DD	7.4	119	53	57	+1.6	+1.9
Apr 26 19:53	139528	DD	7.2	169	34	186	-0.6	-3.8	Aug 13 21:23	1950	DD	5.7	63	11	85	+0.3	+1.3	Nov 14 22:31	3478	DD	6.4	119	46	34	+0.8	+2.5
Apr 27 04:44	2008	DD	6.6	173	15	144	+0.4	-0.8	Aug 16 20:16	2338	DD	6.4	102	63	53	+2.5	+3.6	Nov 15 22:49	128698	DD	7.0					

LUNAR OCCULTATION TABLE

DARWIN (12° 23' S, 130° 44' E)

ACST	OBJECT	PD Mag	Elg	Alt	PA	A	B	ACST	OBJECT	PD Mag	Elg	Alt	PA	A	B	ACST	OBJECT	PD Mag	Elg	Alt	PA	A	B
Jan 03 06:17	1484	DB	3.5	134	46	105	+1.9 -0.3	Jun 01 05:49	3116	RD	6.6	114	80	293	+4.7 -1.9	Sep 18 21:29	3175	DD	4.7	146	72	67	+2.9 +1.1
Jan 09 04:37	2196	RD	6.5	56	27	277	+0.9 -0.7	Jun 06 05:32	165	RD	6.4	58	37	222	+1.0 +1.6	Sep 18 23:11	3175	RB	4.7	146	80	233	+2.4 +2.0
Jan 29 21:04	1393	RD	6.5	171	16	241	+0.4 +0.7	Jun 18 22:03	1773	DD	5.0	96	47	111	+1.7 -0.6	Sep 20 23:48	3428	DD	5.0	168	84	11	+0.8 +3.9
Feb 01 05:33	1689	DB	5.2	140	56	96	+2.5 0.0	Jun 18 23:13	1773	RB	5.0	96	30	318	+0.7 -1.3	Sep 26 05:25	450	RD	6.4	134	51	246	+2.7 +1.4
Feb 04 03:51	2043	RD	6.5	100	56	9	-1.2 -5.3	Jun 20 22:44	2020	DD	6.5	123	64	110	+2.4 -0.7	Sep 28 02:55	709	DB	4.3	112	43	5	-0.7 +4.2
Feb 25 02:03	1208	DD	6.4	141	27	118	+0.8 -0.5	Jun 20 23:51	2022	DD	5.5	124	48	185	+0.3 -5.8	Sep 28 03:46	709	RD	4.3	112	50	299	+4.8 -2.6
Feb 27 02:41	1484	DD	3.5	169	46	86	+2.4 +0.5	Jun 23 04:04	2303	DD	4.8	152	14	152	+1.2 -2.4	Oct 12 12:27	2672	DD	2.8	77	13	94	+0.2 -0.5
Feb 27 03:38	1484	RB	3.5	169	35	337	+0.2 -2.1	Jun 23 04:05	2302	DD	2.6	152	14	153	+1.3 -2.5	Oct 12 13:28	2672	RB	2.8	78	27	293	+0.5 -1.2
Mar 01 02:47	1739	RD	6.4	160	71	354	+0.3 -3.4	Jun 23 04:39	2302	RB	2.6	152	6	223	-0.7 +2.6	Oct 18 21:48	3506	DD	6.1	150	74	344	-1.7 +7.0
Mar 08 04:00	2694	RD	6.5	69	28	325	-0.2 -2.6	Jun 28 23:09	3175	DB	4.7	135	19	67	+0.9 +0.4	Oct 20 01:10	76	DD	5.9	161	63	10	+0.6 +3.7
Mar 23 20:03	1117	RB	5.0	106	53	284	+3.0 -0.6	Jun 29 00:23	3175	RD	4.7	135	37	269	+1.5 -0.4	Oct 25 01:48	657	RD	5.3	143	51	305	+6.0 -3.9
Apr 01 23:12	2322	RD	4.1	127	16	263	+0.6 -0.2	Jul 20 19:38	2376	DD	4.5	132	62	174	-0.3 -4.7	Oct 30 03:50	1363	RD	5.2	83	27	319	+1.9 -2.4
Apr 01 23:12	159763	RD	5.4	127	16	263	+0.6 -0.2	Jul 20 20:26	2376	RB	4.5	132	73	241	+4.5 +2.2	Oct 30 04:26	1365	RD	6.0	83	34	318	+2.2 -2.4
Apr 02 01:54	2338	RD	6.4	126	53	253	+2.8 +0.6	Jul 21 19:43	2523	DD	4.8	145	51	122	+1.3 -1.6	Nov 08 20:57	2652	DD	6.5	48	18	95	+0.6 +0.3
Apr 02 03:21	2343	RD	6.3	125	73	288	+2.5 -1.0	Jul 21 21:08	2523	RB	4.8	145	69	279	+2.7 -0.7	Nov 11 23:16	3106	DD	5.2	86	24	76	+0.6 +0.9
Apr 16 19:03	628	DD	4.9	40	27	114	+1.3 -0.6	Jul 23 04:38	2719	DD	5.8	160	17	101	+0.6 +0.1	Nov 22 05:24	767	RD	5.5	161	27	248	+1.9 +1.3
Apr 16 20:07	628	RB	4.9	40	14	229	+1.3 +2.0	Jul 24 00:25	2861	DD	5.6	170	77	74	+3.1 +0.9	Nov 23 00:07	900	DB	4.8	151	37	39	+0.9 +1.8
Apr 22 22:18	1484	DD	3.5	116	54	180	-0.5 -4.2	Jul 24 01:00	2864	DD	4.6	171	74	120	+3.8 -2.0	Nov 23 01:24	900	RD	4.8	150	48	287	+3.4 -1.1
Apr 22 23:02	1484	RB	3.5	116	47	247	+3.6 +2.0	Jul 24 02:09	2864	RB	4.6	171	61	211	+1.1 +3.5	Nov 28 04:17	1570	DB	5.5	88	40	102	+2.0 -0.9
Apr 27 23:10	2110	RD	6.3	173	60	296	+1.7 -1.3	Jul 31 02:26	192	DB	5.1	108	41	41	+1.1 +1.7	Nov 28 05:39	1570	RD	5.5	87	56	318	+2.0 -2.1
May 01 23:44	2719	RD	5.8	121	16	238	+1.1 +0.8	Jul 31 03:52	192	RD	5.1	108	61	239	+2.3 +1.2	Nov 29 04:19	1687	RD	6.2	75	32	354	+0.7 -3.9
May 05 04:09	3164	DB	4.5	84	40	125	+1.5 -2.9	Aug 11 20:06	1702	DD	4.0	36	15	183	-0.5 -4.0	Dec 09 20:00	3175	DD	4.7	64	50	57	+1.3 +1.7
May 05 05:07	3164	RD	4.5	84	54	204	+2.3 +3.9	Aug 11 20:32	1702	RB	4.0	36	9	236	+0.8 +2.8	Dec 09 21:14	3175	RB	4.7	65	33	239	+0.6 +1.4
May 21 20:17	1689	DD	5.2	111	69	182	-0.1 -4.3	Aug 19 00:50	2659	DD	6.2	129	39	38	+0.4 +2.9	Dec 11 20:40	3428	DD	5.0	87	62	4	-0.1 +4.0
May 21 21:09	1689	RB	5.2	112	67	257	+4.2 +1.1	Aug 19 21:50	2809	DD	4.9	140	76	101	+3.3 -0.7	Dec 11 21:39	3428	RB	5.0	88	47	277	+2.6 +0.1
May 24 02:40	1950	DD	5.7	141	25	63	+1.1 +2.2	Aug 19 23:27	2809	RB	4.9	141	68	244	+2.5 +1.6	Dec 17 00:04	450	DD	6.4	144	50	101	+3.4 -0.3
May 26 03:34	2209	DD	5.6	169	39	68	+1.4 +1.6	Aug 20 03:55	2834	DD	5.0	142	11	56	-0.3 +1.3	Dec 18 21:27	709	DD	4.3	166	42	68	+1.9 +0.6
May 29 00:40	2659	RD	6.2	152	58	299	+1.8 -1.5	Aug 21 23:59	3089	DD	5.3	164	81	112	+4.5 -1.9	Dec 18 23:00	709	RB	4.3	166	53	237	+2.5 +1.3
Jun 01 02:06	3106	DB	5.2	115	41	50	+2.0 +0.6	Sep 01 06:30	NGC174	RD	8.0	81	52	314	+5.8 -4.6	Dec 22 23:05	1274	RD	5.7	146	19	325	+2.1 -3.1
Jun 01 03:29	3106	RD	5.2	115	61	282	+2.9 -1.1	Sep 03 04:12	1055	RD	5.7	58	11	213	-0.5 +1.8	Dec 22 23:49	1279	RD	6.3	145	28	335	+2.8 -4.3

LUNAR OCCULTATION TABLE

HOBART (42° 48' S, 147° 13'E)

AEST	OBJECT	PD Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD Mag	Elg	Alt	PA	A	B	AEST	OBJECT	PD Mag	Elg	Alt	PA	A	B
Jan 05 00:06	1701	RD	4.8	110	6	283	+0.4 -1.6	Jun 08 06:22	384	RD	5.6	36	18	252	+1.0 -0.7	Sep 28 03:46	709	DB	4.3	112	24	125	+3.1 -1.7
Jan 05 01:05	1707	RD	5.3	110	16	342	+0.6 -2.5	Jun 27 01:22	2907	RD	6.2	158	70	244	+1.9 +1.0	Sep 28 04:36	709	RD	4.3	112	24	195	+1.0 +2.1
Jan 22 21:59	384	DD	5.6	98	19	28	+1.0 +2.4	Jul 01 01:38	3428	DB	5.0	112	36	24	+0.9 +1.7	Oct 12 14:04	2672	DD	2.8	78	47	172	-1.2 -6.7
Jan 24 21:37	628	DD	4.9	122	24	24	+1.4 +2.1	Jul 01 02:41	3428	RD	5.0	112	46	280	+2.0 -1.8	Oct 12 14:27	2672	RB	2.8	78	51	208	+3.3 +4.2
Jan 28 00:28	1117	DD	5.0	161	20	68	+1.9 +1.0	Jul 19 00:20	2110	DD	6.3	107	19	115	+0.4 +0.5	Oct 12 22:45	2719	DD	5.8	81	25	70	+0.1 +1.7
Jan 31 22:38	1651	RD	3.9	143	11	313	+0.7 -1.9	Jul 19 18:58	2218	DD	5.5	118	61	157	+0.7 -2.8	Oct 13 19:30	2864	DD	4.6	92	67	120	+2.4 -1.1
Feb 10 04:10	2875	RD	6.0	28	12	221	+0.5 +0.1	Jul 19 19:59	2218	RB	5.5	119	64	259	+2.3 +0.6	Oct 13 20:23	2861	RB	5.6	92	59	261	+1.5 +1.2
Feb 22 22:02	882	DD	5.0	114	16	82	+1.6 +1.1	Jul 23 19:14	2834	DD	5.0	169	35	125	+0.3 -2.4	Oct 13 20:29	2864	RB	4.6	92	58	214	+0.7 +3.2
Feb 23 19:56	1030	RB	3.1	126	21	227	+1.6 +0.5	Jul 25 01:02	2991	RD	6.1	176	69	295	+2.5 -1.1	Oct 20 01:18	76	DD	5.9	161	37	113	+2.7 +0.3
Feb 27 03:32	1484	DD	3.5	169	12	152	+0.1 -0.6	Jul 29 03:13	3506	RD	6.1	130	53	219	+1.3 +1.7	Oct 24 23:08	634	RD	5.3	144	12	243	+0.8 -0.5
Mar 06 03:57	2394	RD	6.2	93	56	357	-0.6 -5.3	Aug 03 04:24	517	RD	6.1	75	20	227	+0.8 +0.1	Oct 25 01:39	656	DB	4.2	143	24	90	+2.2 -0.4
Mar 08 03:56	2692	DB	5.5	69	40	92	+0.9 -1.4	Aug 04 06:04	665	RD	5.7	62	21	216	+0.8 +0.6	Oct 25 02:44	657	RD	5.3	143	25	199	+1.2 +1.8
Mar 09 03:06	2836	RD	5.5	58	22	206	+1.7 +1.8	Aug 13 21:14	1950	DD	5.7	63	16	118	+0.4 +0.4	Oct 25 03:00	656	RD	4.2	143	25	226	+1.7 +1.2
Mar 23 20:13	1117	DD	5.0	106	22	162	+1.0 -2.0	Aug 15 23:55	2209	DD	5.6	91	13	138	+0.4 -0.2	Nov 06 17:02	2302	DD	2.6	19	37	64	+0.7 +2.4
Mar 23 20:49	1117	RB	5.0	106	20	214	+2.8 +2.7	Aug 16 21:11	2343	DD	6.3	103	53	85	+1.5 +1.2	Nov 06 17:52	2302	RB	2.6	20	28	322	+0.9 -0.5
Mar 27 19:55	1651	DD	3.9	160	20	77	+1.2 -1.0	Aug 20 04:14	2836	DD	5.5	143	11	30	-0.8 +2.3	Nov 09 20:20	2809	RB	4.9	60	37	232	+0.2 +2.2
Mar 27 20:46	1651	RB	3.9	160	27	337	+0.9 -2.1	Aug 22 01:50	3092	DD	6.2	165	52	132	+3.4 -1.8	Nov 11 20:38	3092	DD	6.2	85	50	360	-0.9 +4.9
Apr 01 04:15	2193	RD	6.1	139	58	295	+1.6 -0.4	Sep 10 19:26	2022	DD	5.5	45	24	168	+0.6 -2.1	Nov 21 23:05	742	RD	5.8	163	18	231	+1.1 0.0
Apr 28 00:10	2110	DD	6.3	173	60	204	+9.9 +9.9	Sep 12 22:23	2303	DD	4.8	73	18	151	+0.8 -0.9	Nov 23 02:08	900	RD	4.8	150	21	193	+1.4 +2.9
Apr 28 00:18	2110	RD	6.3	173	60	218	+9.9 +9.9	Sep 12 22:23	2302	DD	2.6	73	18	152	+0.8 -1.0	Dec 06 08:56	2672	DD	2.8	23	30	140	-0.2 -2.5
May 20 22:06	1570	DD	5.5	98	20	54	+2.7 +4.1	Sep 12 22:58	2302	RB	2.6	74	12	228	-0.5 +2.8	Dec 06 09:45	2672	RB	2.8	23	39	241	+1.2 -0.3
May 21 20:25	1687	DD	6.2	111	38	98	+1.9 0.0	Sep 14 23:22	2607	DD	5.9	99	30	36	-0.3 +3.2	Dec 07 21:20	2907	DD	6.2	41	13	49	-0.5 +1.8
May 23 00:50	1813	DD	5.7	126	20	61	+1.3 +3.4	Sep 14 23:50	NGC653	DD	6.0	99	25	29	-0.7 +3.5	Dec 11 21:18	3428	RB	5.0	88	37	175	-0.7 +3.7
May 25 23:46	2193	DD	6.1	167	62	90	+2.0 +0.2	Sep 15 22:25	2767	DD	6.3	111	51	85	+1.3 +1.3	Dec 14 21:14	219	DD	4.8	121	39	61	+1.7 +1.3
May 26 05:05	2213	DD	5.8	170	15	132	+0.4 0.0	Sep 15 23:30	2771	DD	5.6	111	39	82	+0.8 +1.5	Dec 14 22:37	219	RB	4.8	121	31	230	+1.2 +1.9
May 26 20:06	2322	DD	4.1	178	35	164	-0.3 -2.9	Sep 16 20:51	2907	DD	6.2	122	70	56	+1.7 +1.8	Dec 19 01:11	716	DD	6.3	166	18	75	+1.7 +1.2
May 26 20:47	2322	RD	4.1	178	42	245	+1.6 -0.4	Sep 21 00:10	3425	DD	4.4	168	55	10	+0.4 +3.2	Dec 23 00:33	1274	RD	5.7	146	17	234	+1.5 -0.1
May 30 03:18	2834	DB	5.0	139	71	91	+2.0 0.0	Sep 21 01:08	3425	RB	4.4	169	50	279	+2.4 +0.5	Dec 23 01:33	1279	RD	6.3	145	22	254	+2.0 -0.2
May 30 04:41	2834	RD	5.0	139	63	252	+1.6 +1.4	Sep 24 00:55	219	DB	4.8	157	40	37	+1.2 +1.3	Dec 31 13:16	2302	DB	2.6	36	39	51	+0.7 +3.5
Jun 01 00:53	3092	RD	6.2	116	37	268	+0.9 -1.3	Sep 24 02:17	219	RD	4.8	157	40	248	+1.9 +1.0	Dec 31 13:56	2302	RD	2.6	36	32	336	+1.2 -1.6

MERCURY

RISE AND SET TIMES

AEST (Adelaide & Darwin ACST)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set		
Jan	5	06:27	20:42	06:17	19:58	06:15	20:31	07:44	20:29	06:01	21:00	06:24	20:54	06:09	20:19	06:58	20:07	Jan	5
	12	06:47	20:39	06:33	19:57	06:34	20:27	07:55	20:33	06:24	20:52	06:45	20:49	06:28	20:16	07:11	20:09		12
	19	06:42	20:14	06:26	19:35	06:30	20:02	07:44	20:14	06:23	20:24	06:42	20:23	06:24	19:52	07:02	19:49		19
	26	05:57	19:23	05:41	18:44	05:44	19:11	06:57	19:24	05:38	19:33	05:57	19:32	05:38	19:01	06:16	18:59		26
Feb	2	04:51	18:28	04:36	17:48	04:39	18:16	05:55	18:25	04:31	18:40	04:51	18:38	04:33	18:05	05:13	18:01	Feb	2
	9	04:06	17:55	03:53	17:14	03:54	17:44	05:14	17:49	03:44	18:09	04:05	18:06	03:48	17:33	04:30	17:26		9
	16	03:48	17:43	03:35	17:01	03:35	17:32	04:58	17:36	03:25	17:58	03:46	17:54	03:30	17:21	04:13	17:13		16
	23	03:48	17:42	03:34	17:00	03:35	17:31	04:57	17:36	03:25	17:56	03:46	17:53	03:29	17:19	04:13	17:12		23
Mar	2	03:59	17:45	03:44	17:04	03:46	17:33	05:05	17:41	03:37	17:57	03:57	17:55	03:40	17:22	04:22	17:17	Mar	2
	9	04:17	17:49	04:01	17:10	04:05	17:37	05:19	17:51	03:58	17:59	04:17	17:58	03:59	17:27	04:37	17:25		9
	16	04:42	17:52	04:23	17:16	04:29	17:41	05:36	18:01	04:26	17:59	04:42	18:00	04:22	17:31	04:56	17:33		16
	23	05:11	17:56	04:48	17:23	04:58	17:44	05:56	18:14	05:00	17:58	05:13	18:02	04:51	17:34	05:18	17:43		23
Apr	30	05:45	17:59	05:18	17:31	05:33	17:47	06:19	18:28	05:39	17:56	05:49	18:04	05:24	17:39	05:45	17:55		30
	6	06:24	18:04	05:53	17:40	06:12	17:52	06:47	18:45	06:23	17:56	06:30	18:07	06:03	17:44	06:15	18:08	Apr	6
	13	07:08	18:11	06:32	17:52	06:56	17:59	07:18	19:04	07:14	17:56	07:16	18:12	06:46	17:52	06:50	18:24		13
	20	07:52	18:19	07:12	18:05	07:40	18:07	07:50	19:25	08:04	17:59	08:02	18:18	07:29	18:01	07:25	18:42		20
May	27	08:26	18:26	07:42	18:15	08:15	18:13	08:14	19:41	08:43	18:01	08:38	18:23	08:03	18:08	07:52	18:55		27
	4	08:43	18:27	07:57	18:18	08:32	18:14	08:26	19:47	09:03	17:59	08:56	18:24	08:20	18:10	08:05	19:00	May	4
	11	08:38	18:19	07:52	18:10	08:27	18:06	08:20	19:39	08:58	17:51	08:51	18:15	08:15	18:01	08:00	18:52		11
	18	08:11	17:59	07:26	17:49	08:00	17:47	07:56	19:16	08:29	17:32	08:23	17:56	07:48	17:41	07:34	18:30		18
Jun	25	07:26	17:29	06:43	17:17	07:15	17:17	07:16	18:41	07:41	17:05	07:37	17:27	07:03	17:11	06:53	17:56		25
	1	06:36	16:55	05:55	16:41	06:25	16:43	06:31	18:01	06:49	16:34	06:46	16:54	06:14	16:37	06:08	17:18	Jun	1
	8	05:57	16:25	05:17	16:10	05:45	16:13	05:55	17:28	06:08	16:05	06:06	16:24	05:34	16:07	05:30	16:46		8
	15	05:36	16:03	04:56	15:48	05:24	15:51	05:34	17:08	05:47	15:43	05:45	16:03	05:13	15:45	05:09	16:25		15
Jul	22	05:33	15:52	04:52	15:38	05:21	15:39	05:28	16:59	05:46	15:30	05:43	15:50	05:10	15:33	05:04	16:16		22
	29	05:46	15:51	05:03	15:39	05:35	15:39	05:36	17:04	06:02	15:27	05:57	15:49	05:23	15:33	05:13	16:19		29
	6	06:13	16:05	05:28	15:55	06:02	15:52	05:58	17:23	06:31	15:38	06:25	16:02	05:50	15:47	05:36	16:36	Jul	6
	13	06:48	16:34	06:02	16:25	06:37	16:21	06:31	17:54	07:07	16:06	07:00	16:31	06:24	16:16	06:10	17:07		13
Aug	20	07:21	17:16	06:36	17:05	07:10	17:03	07:07	18:33	07:39	16:49	07:33	17:13	06:58	16:58	06:45	17:46		20
	27	07:45	17:59	07:03	17:46	07:33	17:47	07:37	19:09	07:59	17:37	07:56	17:58	07:22	17:41	07:14	18:25		27
	3	07:57	18:39	07:19	18:22	07:46	18:26	07:59	19:39	08:07	18:20	08:06	18:38	07:35	18:20	07:33	18:57	Aug	3
	10	08:01	19:11	07:26	18:50	07:49	18:58	08:13	20:01	08:06	18:58	08:09	19:12	07:39	18:51	07:44	19:22		10
Sep	17	07:58	19:36	07:27	19:12	07:47	19:24	08:20	20:16	07:59	19:28	08:04	19:39	07:37	19:16	07:49	19:40		17
	24	07:51	19:55	07:23	19:27	07:39	19:43	08:22	20:26	07:47	19:51	07:56	20:00	07:31	19:34	07:48	19:52		24
	31	07:40	20:06	07:15	19:36	07:27	19:55	08:18	20:29	07:32	20:06	07:43	20:12	07:20	19:45	07:42	19:58		31
	7	07:23	20:08	07:01	19:35	07:11	19:56	08:08	20:24	07:12	20:10	07:25	20:15	07:03	19:46	07:31	19:55	Sep	7
Oct	14	06:59	19:53	06:39	19:19	06:47	19:41	07:48	20:06	06:47	19:57	07:01	20:00	06:40	19:32	07:10	19:37		14
	21	06:27	19:14	06:05	18:41	06:15	19:02	07:14	19:29	06:15	19:17	06:29	19:21	06:07	18:52	06:36	19:00		21
	28	05:47	18:11	05:23	17:41	05:35	17:59	06:27	18:35	05:39	18:11	05:51	18:17	05:28	17:51	05:51	18:03		28
	5	05:15	17:16	04:47	16:49	05:03	17:04	05:46	17:48	05:10	17:12	05:19	17:21	04:54	16:56	05:12	17:14	Oct	5
Nov	12	04:59	16:58	04:31	16:31	04:47	16:46	05:28	17:31	04:55	16:53	05:04	17:02	04:38	16:38	04:55	16:56		12
	19	04:55	17:11	04:29	16:42	04:43	16:59	05:30	17:38	04:49	17:09	04:59	17:16	04:35	16:50	04:55	17:05		19
	26	04:55	17:37	04:32	17:05	04:43	17:25	05:39	17:56	04:45	17:39	04:58	17:44	04:36	17:16	05:02	17:25		26
	2	04:57	18:07	04:38	17:31	04:45	17:55	05:50	18:15	04:42	18:13	04:58	18:15	04:38	17:45	05:10	17:48	Nov	2
Dec	9	05:00	18:36	04:44	17:57	04:47	18:25	06:02	18:36	04:41	18:47	04:59	18:46	04:41	18:14	05:20	18:10		9
	16	05:05	19:05	04:52	18:22	04:52	18:54	06:15	18:56	04:41	19:20	05:03	19:16	04:46	18:42	05:31	18:33		16
	23	05:12	19:33	05:02	18:48	04:59	19:22	06:30	19:17	04:45	19:52	05:09	19:46	04:54	19:10	05:43	18:56		23
	30	05:23	20:00	05:15	19:12	05:10	19:48	06:46	19:39	04:53	20:21	05:19	20:13	05:06	19:36	05:59	19:19		30
Dec	7	05:39	20:23	05:32	19:35	05:26	20:12	07:05	20:00	05:07	20:47	05:34	20:37	05:22	20:00	06:16	19:40	Dec	7
	14	05:58	20:42	05:52	19:54	05:45	20:31	07:24	20:19	05:26	21:05	05:54	20:56	05:41	20:18	06:36	19:59		14
	21	06:19	20:53	06:11	20:06	06:06	20:42	07:42	20:33	05:49	21:14	06:15	21:06	06:02	20:30	06:54	20:13		21
	28	06:33	20:50	06:23	20:06	06:20	20:39	07:50	20:36	06:06	21:09	06:30	21:03	06:15	20:27	07:04	20:14		28

MERCURY

GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE			
	R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		R.A. hh mm ss	Dec. ° ' "		
1	19 51 48	- 23 02 41		20 16 14	- 16 04 24		21 09 37	- 17 24 22		00 19 25	+ 00 14 46		03 52 29	+ 22 51 19		04 07 25	+ 17 53 29		
2	19 58 18	- 22 41 34		20 12 20	- 16 20 32		21 14 53	- 17 08 50		00 26 26	+ 01 06 47		03 57 27	+ 23 08 01		04 05 44	+ 17 36 07		
3	20 04 42	- 22 19 06		20 08 58	- 16 36 35		21 20 13	- 16 51 58		00 33 31	+ 01 59 37		04 02 08	+ 23 22 21		04 04 14	+ 17 20 21		
4	20 10 57	- 21 55 20		20 06 09	- 16 52 16		21 25 39	- 16 33 49		00 40 40	+ 02 53 11		04 06 30	+ 23 34 20		04 02 57	+ 17 06 20		
5	20 17 03	- 21 30 23		20 03 56	- 17 07 23		21 31 09	- 16 14 22		00 47 54	+ 03 47 24		04 10 33	+ 23 44 01		04 01 54	+ 16 54 12		
6	20 22 58	- 21 04 19		20 02 19	- 17 21 46		21 36 43	- 15 53 37		00 55 13	+ 04 42 12		04 14 16	+ 23 51 28		04 01 06	+ 16 44 02		
7	20 28 40	- 20 37 18		20 01 16	- 17 35 17		21 42 20	- 15 31 34		01 02 35	+ 05 37 27		04 17 40	+ 23 56 44		04 00 34	+ 16 35 54		
8	20 34 08	- 20 09 27		20 00 46	- 17 47 49		21 48 02	- 15 08 15		01 10 02	+ 06 33 03		04 20 43	+ 23 59 52		04 00 18	+ 16 29 49		
9	20 39 20	- 19 40 57		20 00 49	- 17 59 17		21 53 47	- 14 43 39		01 17 33	+ 07 28 51		04 23 25	+ 24 00 53		04 00 19	+ 16 25 49		
10	20 44 13	- 19 12 01		20 01 21	- 18 09 39		21 59 34	- 14 17 47		01 25 08	+ 08 24 42		04 25 47	+ 23 59 52		04 00 37	+ 16 23 53		
11	20 48 45	- 18 42 53		20 02 22	- 18 18 50		22 05 25	- 13 50 40		01 32 45	+ 09 20 26		04 27 47	+ 23 56 50		04 01 12	+ 16 23 59		
12	20 52 53	- 18 13 50		20 03 49	- 18 26 49		22 11 19	- 13 22 16		01 40 26	+ 10 15 52		04 29 25	+ 23 51 52		04 02 05	+ 16 26 04		
13	20 56 33	- 17 45 10		20 05 40	- 18 33 35		22 17 16	- 12 52 38		01 48 08	+ 11 10 48		04 30 43	+ 23 44 59		04 03 16	+ 16 30 04		
14	20 59 44	- 17 17 13		20 07 54	- 18 39 05		22 23 16	- 12 21 45		01 55 52	+ 12 05 03		04 31 38	+ 23 36 15		04 04 44	+ 16 35 55		
15	21 02 21	- 16 50 22		20 10 28	- 18 43 18		22 29 18	- 11 49 39		02 03 35	+ 12 58 23		04 32 13	+ 23 25 44		04 06 30	+ 16 43 31		
16	21 04 22	- 16 25 00		20 13 21	- 18 46 14		22 35 23	- 11 16 18		02 11 19	+ 13 50 35		04 32 27	+ 23 13 29		04 08 33	+ 16 52 48		
17	21 05 44	- 16 01 32		20 16 31	- 18 47 52		22 41 30	- 10 41 44		02 19 00	+ 14 41 27		04 32 21	+ 22 59 35		04 10 53	+ 17 03 38		
18	21 06 23	- 15 40 22		20 19 56	- 18 48 11		22 47 41	- 10 05 58		02 26 39	+ 15 30 47		04 31 56	+ 22 44 07		04 13 31	+ 17 15 56		
19	21 06 18	- 15 21 53		20 23 36	- 18 47 11		22 53 54	- 09 29 00		02 34 13	+ 16 18 22		04 31 13	+ 22 27 12		04 16 25	+ 17 29 34		
20	21 05 27	- 15 06 26		20 27 29	- 18 44 52		23 00 09	- 08 50 50		02 41 42	+ 17 04 03		04 30 12	+ 22 08 56		04 19 37	+ 17 44 26		
21	21 03 50	- 14 54 19		20 31 34	- 18 41 13		23 06 28	- 08 11 29		02 49 04	+ 17 47 39		04 28 56	+ 21 49 27		04 23 05	+ 18 00 25		
22	21 01 28	- 14 45 44		20 35 50	- 18 36 15		23 12 49	- 07 30 57		02 56 18	+ 18 29 03		04 27 26	+ 21 28 57		04 26 51	+ 18 17 24		
23	20 58 23	- 14 40 47		20 40 15	- 18 29 58		23 19 13	- 06 49 17		03 03 23	+ 19 08 07		04 25 44	+ 21 07 34		04 30 53	+ 18 35 13		
24	20 54 39	- 14 39 28		20 44 50	- 18 22 20		23 25 41	- 06 06 28		03 10 18	+ 19 44 48		04 23 52	+ 20 45 32		04 35 11	+ 18 53 47		
25	20 50 23	- 14 41 39		20 49 33	- 18 13 23		23 32 11	- 05 22 31		03 17 01	+ 20 19 00		04 21 52	+ 20 23 02		04 39 46	+ 19 12 56		
26	20 45 40	- 14 47 04		20 54 24	- 18 03 07		23 38 45	- 04 37 27		03 23 32	+ 20 50 41		04 19 46	+ 20 00 20		04 44 38	+ 19 32 33		
27	20 40 40	- 14 55 23		20 59 22	- 17 51 31		23 45 22	- 03 51 18		03 29 50	+ 21 19 51		04 17 37	+ 19 37 40		04 49 47	+ 19 52 28		
28	20 35 31	- 15 06 09		21 04 27	- 17 38 36		23 52 03	- 03 04 06		03 35 53	+ 21 46 29		04 15 27	+ 19 15 17		04 55 12	+ 20 12 33		
29	20 30 21	- 15 18 55					23 58 48	- 02 15 51		03 41 41	+ 22 10 35		04 13 19	+ 18 53 26		05 00 54	+ 20 32 38		
30	20 25 20	- 15 33 11					00 05 36	- 01 26 36		03 47 13	+ 22 32 11		04 11 14	+ 18 32 21		05 06 53	+ 20 52 34		
31	20 20 36	- 15 48 29					00 12 28	- 00 36 22					04 09 16	+ 18 12 18					
	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER			
1	05 13 08	+ 21 12 10		09 32 32	+ 16 19 54		12 16 31	- 04 16 40		12 01 36	- 01 53 10		13 53 45	- 10 15 45		17 06 43	- 24 38 27		
2	05 19 40	+ 21 31 17		09 39 49	+ 15 40 43		12 19 46	- 04 47 47		11 59 02	- 01 14 16		13 59 57	- 10 56 00		17 13 28	- 24 50 43		
3	05 26 28	+ 21 49 42		09 46 57	+ 15 00 47		12 22 52	- 05 17 39		11 56 56	- 00 38 29		14 06 11	- 11 35 49		17 20 13	- 25 01 40		
4	05 33 33	+ 22 07 15		09 53 55	+ 14 20 12		12 25 47	- 05 46 10		11 55 23	- 00 06 35		14 12 24	- 12 15 08		17 27 00	- 25 11 18		
5	05 40 54	+ 22 23 45		10 00 44	+ 13 39 06		12 28 31	- 06 13 15		11 54 25	+ 00 20 49		14 18 39	- 12 53 54		17 33 46	- 25 19 33		
6	05 48 30	+ 22 38 58		10 07 24	+ 12 57 32		12 31 03	- 06 38 45		11 54 03	+ 00 43 17		14 24 54	- 13 32 04		17 40 34	- 25 26 27		
7	05 56 21	+ 22 52 44		10 13 55	+ 12 15 35		12 33 23	- 07 02 34		11 54 19	+ 01 00 30		14 31 09	- 14 09 35		17 47 21	- 25 31 56		
8	06 04 26	+ 23 04 49		10 20 18	+ 11 33 22		12 35 29	- 07 24 33		11 55 11	+ 01 12 19		14 37 26	- 14 46 25		17 54 07	- 25 36 01		
9	06 12 45	+ 23 15 04		10 26 32	+ 10 50 55		12 37 20	- 07 44 33		11 56 40	+ 01 18 44		14 43 43	- 15 22 32		18 00 54	- 25 38 40		
10	06 21 17	+ 23 23 15		10 32 38	+ 10 08 19		12 38 56	- 08 02 23		11 58 43	+ 01 19 49		14 50 00	- 15 57 53		18 07 39	- 25 39 52		
11	06 30 00	+ 23 29 14		10 38 36	+ 09 25 38		12 40 15	- 08 17 53		12 01 18	+ 01 15 46		14 56 19	- 16 32 26		18 14 23	- 25 39 36		
12	06 38 52	+ 23 32 51		10 44 27	+ 08 42 55		12 41 16	- 08 30 52		12 04 23	+ 01 06 52		15 02 38	- 17 06 10		18 21 05	- 25 37 52		
13	06 47 53	+ 23 33 57		10 50 10	+ 08 00 14		12 41 59	- 08 41 07		12 07 55	+ 00 53 25		15 08 59	- 17 39 03		18 27 44	- 25 34 40		
14	06 57 01	+ 23 32 27		10 55 46	+ 07 17 39		12 42 21	- 08 48 24		12 11 52	+ 00 35 48		15 15 20	- 18 11 04		18 34 21	- 25 29 59		
15	07 06 13	+ 23 28 15		11 01 14	+ 06 35 12		12 42 23	- 08 52 31		12 16 10	+ 00 14 22		15 21 43	- 18 42 10		18 40 54	- 25 23 49		
16	07 15 29	+ 23 21 20		11 06 36	+ 05 52 56		12 42 02	- 08 53 13		12 20 47	- 00 10 27		15 28 06	- 19 12 22		18 47 23	- 25 16 11		
17	07 24 46	+ 23 11 40		11 11 50	+ 05 10 55		12 41 19	- 08 50 18		12 25 41	- 00 38 18		15 34 31	- 19 41 36		18 53 46	- 25 07 06		
18	07 34 03	+ 22 59 17		11 16 58	+ 04 29 12		12 40 13	- 08 43 32		12 30 49	- 01 08 48		15 40 57	- 20 09 51		19 00 03	- 24 56 34		
19	07 43 18	+ 22 44 14		11 21 59	+ 03 47 49		12 38 42	- 08 32 43		12 36 09	- 01 41 34		15 47 25	- 20 37 07		19 06 13	- 24 44 38		
20																			

VENUS

RISE AND SET TIMES

AEST (Adelaide & Darwin ACST)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set		
Jan	5	04:57	19:25	04:48	18:39	04:44	19:14	06:18	19:07	04:28	19:46	04:53	19:38	04:39	19:02	05:31	18:46	Jan	5
	12	05:10	19:33	05:01	18:47	04:58	19:21	06:29	19:17	04:42	19:52	05:07	19:45	04:53	19:09	05:43	18:55		12
	19	05:25	19:38	05:14	18:54	05:12	19:26	06:41	19:25	04:59	19:55	05:22	19:49	05:07	19:15	05:55	19:03		19
	26	05:41	19:40	05:28	18:58	05:28	19:29	06:52	19:32	05:17	19:55	05:38	19:51	05:22	19:17	06:07	19:09		26
Feb	2	05:56	19:40	05:42	19:00	05:44	19:29	07:02	19:38	05:35	19:53	05:55	19:51	05:38	19:18	06:19	19:13	Feb	2
	9	06:12	19:39	05:55	19:01	05:59	19:27	07:12	19:42	05:53	19:48	06:12	19:48	05:53	19:17	06:30	19:16		9
	16	06:27	19:36	06:08	19:00	06:15	19:24	07:20	19:45	06:12	19:42	06:28	19:44	06:08	19:14	06:41	19:17		16
	23	06:42	19:31	06:20	18:58	06:30	19:19	07:29	19:47	06:30	19:34	06:44	19:38	06:22	19:10	06:51	19:17		23
Mar	2	06:56	19:26	06:32	18:55	06:44	19:14	07:36	19:49	06:48	19:26	07:00	19:32	06:36	19:05	07:00	19:17	Mar	2
	9	07:11	19:20	06:44	18:52	06:59	19:08	07:44	19:50	07:05	19:16	07:15	19:25	06:50	18:59	07:09	19:16		9
	16	07:25	19:14	06:56	18:49	07:13	19:02	07:51	19:51	07:23	19:07	07:30	19:18	07:04	18:54	07:19	19:15		16
	23	07:39	19:08	07:07	18:45	07:27	18:56	07:58	19:52	07:40	18:58	07:46	19:11	07:18	18:49	07:28	19:15		23
	30	07:54	19:03	07:19	18:43	07:42	18:51	08:06	19:53	07:58	18:50	08:01	19:05	07:32	18:44	07:37	19:14		30
Apr	6	08:08	18:59	07:31	18:41	07:56	18:46	08:14	19:56	08:16	18:42	08:17	18:59	07:46	18:40	07:47	19:15	Apr	6
	13	08:23	18:55	07:44	18:40	08:11	18:43	08:23	19:59	08:34	18:36	08:33	18:55	08:01	18:37	07:57	19:16		13
	20	08:38	18:54	07:56	18:40	08:26	18:41	08:32	20:03	08:51	18:31	08:48	18:52	08:15	18:36	08:08	19:19		20
	27	08:53	18:54	08:09	18:43	08:41	18:41	08:41	20:08	09:09	18:29	09:04	18:52	08:30	18:36	08:19	19:23		27
May	4	09:07	18:56	08:22	18:47	08:56	18:44	08:51	20:15	09:25	18:29	09:19	18:53	08:44	18:39	08:30	19:28	May	4
	11	09:20	19:01	08:34	18:52	09:09	18:48	09:02	20:22	09:40	18:32	09:33	18:57	08:57	18:43	08:41	19:35		11
	18	09:32	19:08	08:45	19:00	09:21	18:55	09:12	20:31	09:53	18:38	09:45	19:04	09:09	18:51	08:52	19:43		18
	25	09:42	19:17	08:55	19:09	09:31	19:04	09:21	20:40	10:04	18:47	09:55	19:13	09:19	19:00	09:01	19:52		25
Jun	1	09:50	19:28	09:03	19:19	09:39	19:15	09:30	20:50	10:10	18:58	10:03	19:24	09:26	19:10	09:10	20:02	Jun	1
	8	09:55	19:40	09:09	19:30	09:44	19:27	09:37	20:59	10:14	19:12	10:07	19:36	09:31	19:22	09:17	20:12		8
	15	09:57	19:52	09:13	19:42	09:46	19:40	09:43	21:08	10:15	19:26	10:09	19:50	09:34	19:35	09:22	20:22		15
	22	09:57	20:05	09:14	19:53	09:46	19:53	09:48	21:17	10:12	19:42	10:08	20:03	09:34	19:47	09:25	20:32		22
	29	09:54	20:18	09:14	20:03	09:43	20:06	09:51	21:24	10:07	19:57	10:05	20:17	09:32	20:00	09:26	20:41		29
Jul	6	09:50	20:30	09:11	20:13	09:38	20:18	09:52	21:30	09:59	20:12	09:59	20:30	09:28	20:11	09:26	20:49	Jul	6
	13	09:43	20:42	09:07	20:23	09:32	20:29	09:52	21:35	09:50	20:27	09:51	20:43	09:21	20:23	09:24	20:55		13
	20	09:35	20:52	09:02	20:31	09:23	20:40	09:50	21:40	09:39	20:41	09:42	20:54	09:14	20:33	09:21	21:01		20
	27	09:26	21:02	08:55	20:38	09:14	20:50	09:47	21:43	09:26	20:54	09:32	21:05	09:05	20:42	09:16	21:06		27
Aug	3	09:15	21:11	08:47	20:45	09:04	20:59	09:44	21:45	09:13	21:06	09:21	21:15	08:55	20:51	09:11	21:10	Aug	3
	10	09:04	21:19	08:38	20:50	08:52	21:07	09:39	21:46	08:58	21:17	09:08	21:24	08:44	20:58	09:04	21:14		10
	17	08:52	21:26	08:28	20:55	08:40	21:14	09:33	21:47	08:43	21:27	08:55	21:32	08:32	21:05	08:57	21:16		17
	24	08:39	21:32	08:18	20:58	08:27	21:20	09:27	21:46	08:27	21:36	08:41	21:39	08:20	21:11	08:49	21:17		24
	31	08:25	21:37	08:06	21:00	08:13	21:25	09:19	21:44	08:10	21:44	08:26	21:45	08:06	21:15	08:39	21:17		31
Sep	7	08:10	21:40	07:54	21:01	07:58	21:28	09:11	21:41	07:52	21:49	08:10	21:49	07:52	21:17	08:29	21:15	Sep	7
	14	07:54	21:40	07:40	20:59	07:42	21:28	09:00	21:36	07:33	21:53	07:53	21:50	07:36	21:17	08:17	21:11		14
	21	07:36	21:37	07:24	20:54	07:24	21:25	08:48	21:27	07:12	21:52	07:34	21:48	07:18	21:14	08:03	21:04		21
	28	07:16	21:28	07:05	20:44	07:03	21:17	08:31	21:15	06:50	21:46	07:13	21:40	06:58	21:05	07:46	20:53		28
Oct	5	06:52	21:13	06:43	20:27	06:40	21:02	08:11	20:56	06:24	21:32	06:49	21:26	06:35	20:50	07:24	20:35	Oct	5
	12	06:25	20:49	06:16	20:03	06:12	20:38	07:45	20:31	05:56	21:09	06:21	21:01	06:07	20:25	06:58	20:10		12
	19	05:53	20:14	05:44	19:28	05:40	20:03	07:12	19:57	05:25	20:33	05:50	20:26	05:36	19:51	06:26	19:36		19
	26	05:19	19:29	05:08	18:45	05:06	19:17	06:34	19:16	04:53	19:46	05:16	19:41	05:01	19:06	05:49	18:54		26
Nov	2	04:45	18:38	04:32	17:56	04:32	18:27	05:55	18:31	04:21	18:53	04:43	18:49	04:27	18:16	05:11	18:07	Nov	2
	9	04:13	17:49	03:58	17:09	04:01	17:38	05:17	17:48	03:53	18:00	04:12	17:59	03:55	17:27	04:35	17:23		9
	16	03:46	17:07	03:29	16:30	03:34	16:56	04:45	17:11	03:29	17:16	03:46	17:16	03:28	16:45	04:04	16:45		16
	23	03:24	16:35	03:06	15:59	03:12	16:24	04:19	16:43	03:08	16:42	03:25	16:44	03:05	16:14	03:39	16:16		23
	30	03:06	16:13	02:47	15:37	02:54	16:02	03:59	16:22	02:51	16:20	03:07	16:21	02:47	15:51	03:19	15:54		30
Dec	7	02:51	15:59	02:32	15:23	02:39	15:47	03:44	16:08	02:36	16:05	02:52	16:07	02:32	15:37	03:05	15:40	Dec	7
	14	02:39	15:51	02:20	15:15	02:26	15:40	03:33	15:59	02:23	15:58	02:39	16:00	02:20	15:29	02:53	15:31		14
	21	02:29	15:48	02:11	15:11	02:16	15:36	03:26	15:53	02:12	15:56	02:29	15:57	02:10	15:26	02:45	15:26		21
	28	02:20	15:49	02:04	15:10	02:08	15:37	03:20	15:51	02:02	15:58	02:20	15:58	02:02	15:27	02:39	15:25		28

VENUS

GEOCENTRIC POSITION (0hr UT, Epoch 2000.0)

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "	R.A. hh mm ss	Dec. ° ' "
1	18 31 13	- 23 38 51	21 15 57	- 17 15 33	23 29 45	- 04 46 35	01 51 03	+ 10 49 52	04 17 26	+ 22 07 31	07 00 02	+ 24 33 54
2	18 36 42	- 23 36 42	21 20 58	- 16 53 41	23 34 19	- 04 16 20	01 55 42	+ 11 17 59	04 22 34	+ 22 22 21	07 05 14	+ 24 27 25
3	18 42 12	- 23 33 49	21 25 58	- 16 31 21	23 38 53	- 03 45 57	02 00 21	+ 11 45 50	04 27 44	+ 22 36 34	07 10 25	+ 24 20 15
4	18 47 41	- 23 30 13	21 30 57	- 16 08 34	23 43 27	- 03 15 29	02 05 02	+ 12 13 24	04 32 54	+ 22 50 10	07 15 35	+ 24 12 25
5	18 53 10	- 23 25 52	21 35 55	- 15 45 19	23 48 00	- 02 44 55	02 09 43	+ 12 40 41	04 38 05	+ 23 03 07	07 20 44	+ 24 03 54
6	18 58 38	- 23 20 48	21 40 52	- 15 21 39	23 52 33	- 02 14 16	02 14 26	+ 13 07 39	04 43 16	+ 23 15 27	07 25 52	+ 23 54 43
7	19 04 06	- 23 15 01	21 45 47	- 14 57 33	23 57 06	- 01 43 33	02 19 09	+ 13 34 19	04 48 29	+ 23 27 07	07 30 59	+ 23 44 53
8	19 09 33	- 23 08 30	21 50 41	- 14 33 02	00 01 38	- 01 12 47	02 23 53	+ 14 00 39	04 53 42	+ 23 38 08	07 36 05	+ 23 34 24
9	19 15 00	- 23 01 17	21 55 34	- 14 08 08	00 06 10	- 00 41 59	02 28 38	+ 14 26 39	04 58 56	+ 23 48 29	07 41 10	+ 23 23 16
10	19 20 26	- 22 53 21	22 00 26	- 13 42 50	00 10 42	- 00 11 08	02 33 24	+ 14 52 18	05 04 10	+ 23 58 10	07 46 14	+ 23 11 31
11	19 25 52	- 22 44 43	22 05 17	- 13 17 10	00 15 14	+ 00 19 43	02 38 11	+ 15 17 34	05 09 25	+ 24 07 10	07 51 16	+ 22 59 07
12	19 31 17	- 22 35 24	22 10 06	- 12 51 09	00 19 46	+ 00 50 35	02 42 58	+ 15 42 28	05 14 41	+ 24 15 30	07 56 17	+ 22 46 07
13	19 36 41	- 22 25 22	22 14 55	- 12 24 47	00 24 17	+ 01 21 26	02 47 47	+ 16 06 59	05 19 57	+ 24 23 08	08 01 17	+ 22 32 30
14	19 42 04	- 22 14 40	22 19 42	- 11 58 05	00 28 49	+ 01 52 16	02 52 37	+ 16 31 05	05 25 13	+ 24 30 05	08 06 15	+ 22 18 18
15	19 47 26	- 22 03 18	22 24 28	- 11 31 04	00 33 21	+ 02 23 05	02 57 28	+ 16 54 47	05 30 30	+ 24 36 19	08 11 12	+ 22 03 30
16	19 52 47	- 21 51 15	22 29 14	- 11 03 44	00 37 52	+ 02 53 50	03 02 20	+ 17 18 02	05 35 47	+ 24 41 52	08 16 08	+ 21 48 07
17	19 58 08	- 21 38 32	22 33 58	- 10 36 07	00 42 24	+ 03 24 33	03 07 13	+ 17 40 52	05 41 04	+ 24 46 42	08 21 02	+ 21 32 10
18	20 03 27	- 21 25 11	22 38 41	- 10 08 14	00 46 56	+ 03 55 11	03 12 08	+ 18 03 14	05 46 21	+ 24 50 50	08 25 55	+ 21 15 40
19	20 08 45	- 21 11 11	22 43 24	- 09 40 04	00 51 28	+ 04 25 44	03 17 03	+ 18 25 08	05 51 38	+ 24 54 15	08 30 46	+ 20 58 37
20	20 14 03	- 20 56 33	22 48 05	- 09 11 39	00 56 01	+ 04 56 11	03 21 59	+ 18 46 34	05 56 56	+ 24 56 57	08 35 35	+ 20 41 02
21	20 19 19	- 20 41 18	22 52 46	- 08 42 59	01 00 34	+ 05 26 33	03 26 56	+ 19 07 30	06 02 13	+ 24 58 57	08 40 24	+ 20 22 55
22	20 24 34	- 20 25 26	22 57 26	- 08 14 06	01 05 07	+ 05 56 47	03 31 55	+ 19 27 56	06 07 30	+ 25 00 13	08 45 10	+ 20 04 18
23	20 29 47	- 20 08 58	23 02 05	- 07 45 00	01 09 40	+ 06 26 53	03 36 54	+ 19 47 52	06 12 48	+ 25 00 47	08 49 55	+ 19 45 11
24	20 35 00	- 19 51 54	23 06 43	- 07 15 42	01 14 14	+ 06 56 50	03 41 54	+ 20 07 16	06 18 04	+ 25 00 38	08 54 38	+ 19 25 34
25	20 40 12	- 19 34 16	23 11 21	- 06 46 12	01 18 48	+ 07 26 39	03 46 56	+ 20 26 08	06 23 21	+ 24 59 46	08 59 20	+ 19 05 28
26	20 45 22	- 19 16 04	23 15 58	- 06 16 32	01 23 23	+ 07 56 17	03 51 59	+ 20 44 27	06 28 37	+ 24 58 11	09 04 00	+ 18 44 55
27	20 50 31	- 18 57 18	23 20 34	- 05 46 42	01 27 58	+ 08 25 44	03 57 02	+ 21 02 13	06 33 53	+ 24 55 54	09 08 39	+ 18 23 54
28	20 55 38	- 18 38 00	23 25 10	- 05 16 43	01 32 33	+ 08 54 59	04 02 07	+ 21 19 25	06 39 08	+ 24 52 54	09 13 16	+ 18 02 27
29	21 00 45	- 18 18 09			01 37 10	+ 09 24 03	04 07 12	+ 21 36 02	06 44 22	+ 24 49 12	09 17 51	+ 17 40 33
30	21 05 50	- 17 57 47			01 41 47	+ 09 52 53	04 12 19	+ 21 52 05	06 49 36	+ 24 44 48	09 22 25	+ 17 18 15
31	21 10 54	- 17 36 55			01 46 24	+ 10 21 30			06 54 50	+ 24 39 42		
	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
1	09 26 57	+ 16 55 31	11 35 27	+ 02 52 22	13 24 20	- 11 57 49	14 37 23	- 22 01 57	14 13 07	- 19 18 55	14 00 15	- 11 01 47
2	09 31 28	+ 16 32 25	11 39 15	+ 02 22 42	13 27 30	- 12 23 48	14 38 35	- 22 13 19	14 11 00	- 18 55 12	14 01 54	- 11 00 36
3	09 35 57	+ 16 08 55	11 43 02	+ 01 53 00	13 30 37	- 12 49 30	14 39 40	- 22 23 52	14 08 55	- 18 31 00	14 03 39	- 11 00 21
4	09 40 24	+ 15 45 02	11 46 48	+ 01 23 16	13 33 43	- 13 14 54	14 40 38	- 22 33 37	14 06 54	- 18 06 26	14 05 31	- 11 01 02
5	09 44 50	+ 15 20 48	11 50 32	+ 00 53 31	13 36 46	- 13 40 01	14 41 28	- 22 42 29	14 04 57	- 17 41 39	14 07 28	- 11 02 35
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7	09 53 37	+ 14 31 17	11 57 58	- 00 05 59	13 42 47	- 14 29 16	14 42 43	- 22 57 30	14 01 19	- 16 52 00	14 11 41	- 11 08 11
8	09 57 58	+ 14 06 02	12 01 39	- 00 35 44	13 45 45	- 14 53 24	14 43 09	- 23 03 34	13 59 40	- 16 27 24	14 13 55	- 11 12 09
9	10 02 18	+ 13 40 28	12 05 20	- 01 05 26	13 48 40	- 15 17 10	14 43 25	- 23 08 37	13 58 07	- 16 03 07	14 16 15	- 11 16 52
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11	10 10 53	+ 12 48 26	12 12 37	- 02 04 45	13 54 22	- 16 03 37	14 43 32	- 23 15 31	13 55 25	- 15 16 01	14 21 09	- 11 28 20
12	10 15 09	+ 12 22 00	12 16 14	- 02 34 20	13 57 09	- 16 26 16	14 43 22	- 23 17 16	13 54 16	- 14 53 25	14 23 44	- 11 35 03
13	10 19 22	+ 11 55 17	12 19 50	- 03 03 50	13 59 53	- 16 48 31	14 43 03	- 23 17 51	13 53 15	- 14 31 35	14 26 23	- 11 42 21
14	10 23 35	+ 11 28 19	12 23 25	- 03 33 16	14 02 34	- 17 10 21	14 42 34	- 23 17 12	13 52 23	- 14 10 36	14 29 06	- 11 50 13
15	10 27 46	+ 11 01 07	12 26 59	- 04 02 37	14 05 12	- 17 31 45	14 41 56	- 23 15 17	13 51 41	- 13 50 33	14 31 54	- 11 58 37
16	10 31 55	+ 10 33 40	12 30 31	- 04 31 52	14 07 46	- 17 52 42	14 41 09	- 23 12 03	13 51 07	- 13 31 30	14 34 46	- 12 07 31
17	10 36 03	+ 10 06 01	12 34 03	- 05 01 00	14 10 17	- 18 13 11	14 40 12	- 23 07 30	13 50 43	- 13 13 30	14 37 42	- 12 16 54
18	10 40 10	+ 09 38 08	12 37 33	- 05 30 01	14 12 44	- 18 33 12	14 39 07	- 23 01 35	13 50 28	- 12 56 35	14 40 42	- 12 26 42
19	10 44 16	+ 09 10 04	12 41 02	- 05 58 54	14 15 07	- 18 52 43	14 37 53	- 22 54 16	13 50 22	- 12 40 48	14 43 46	- 12 36 56
20	10 48 20	+ 08 41 49	12 44 30	- 06 27 38	14 17 26	- 19 11 44	14 36 31	- 22 45 33	13 50 25	- 12 26 11	14 46 54	- 12 47 32
21	10 52 22	+ 08 13 24	12 47 57	- 06 56 14	14 19 41	- 19 30 13	14 35 02	- 22 35 25	13 50 37	- 12 12 44	14 50 05	- 12 58 29
22	10 56 23	+ 07 44 48	12 51 22	- 07 24 39	14 21 51	- 19 48 10	14 33 24	- 22 23 52	13 50 58	- 12 00 28	14 53 20	- 13 09 45
23	11 00 23	+ 07 16 04	12 54 46	- 07 52 55	14 23 57	- 20 05 33	14 31 41	- 22 10 54	13 51 27	- 11 49 24	14 56 38	- 13 21 19
24	11 04 22	+ 06 47 11	12 58 09	- 08 20 59	14 25 58	- 20 22 21	14 29 51	- 21 56 34	13 52 06	- 11 39 30	14 59 59	- 13 33 09
25	11 08 20	+ 06 18 11	13 01 31	- 08 48 52	14 27 53	- 20 38 33	14 27 55	- 21 40 53	13 52 52	- 11 30 46	15 03 24	- 13 45 14
26	11 12 16	+ 05 49 03	13 04 51	- 09 16 33	14 29 43	- 20 54 08	14 25 55	- 21 23 54	13 53 47	- 11 23 11	15 06 52	- 13 57 31
27	11 16 11	+ <										

MARS

RISE AND SET TIMES

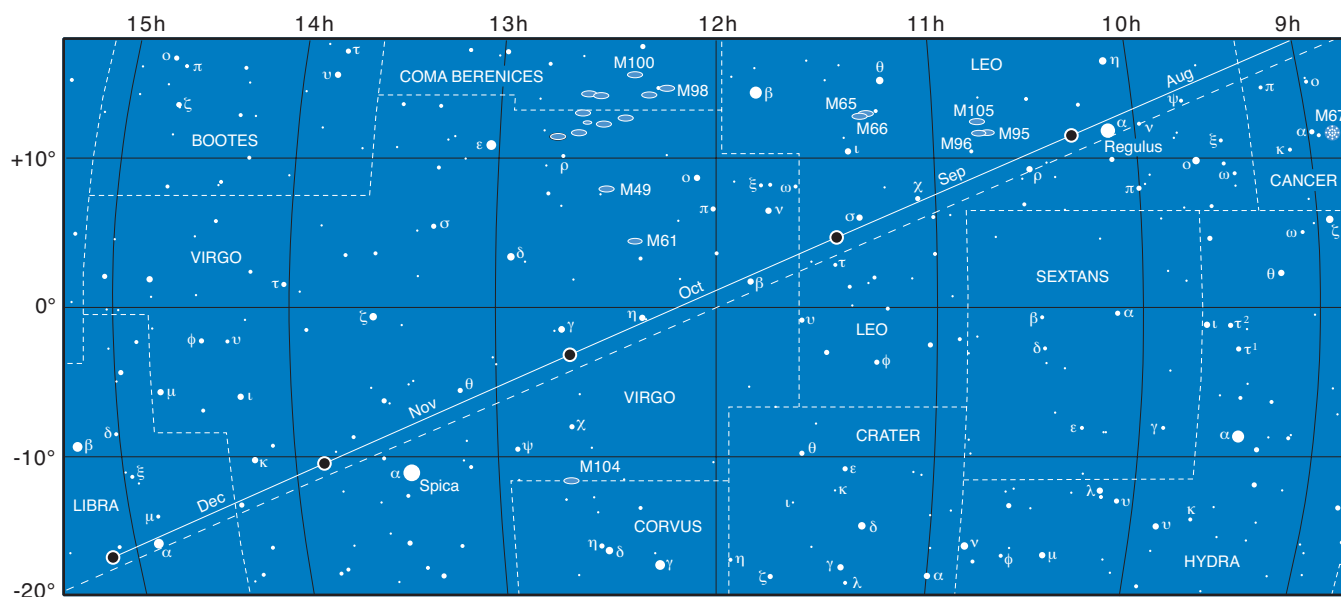
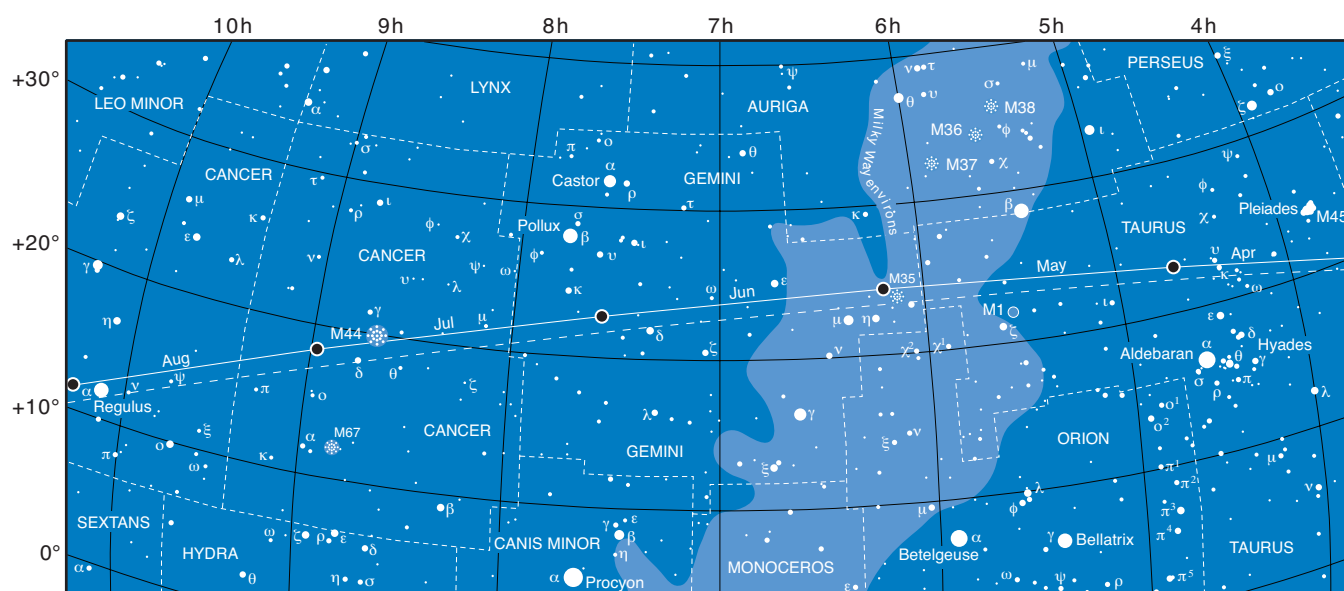
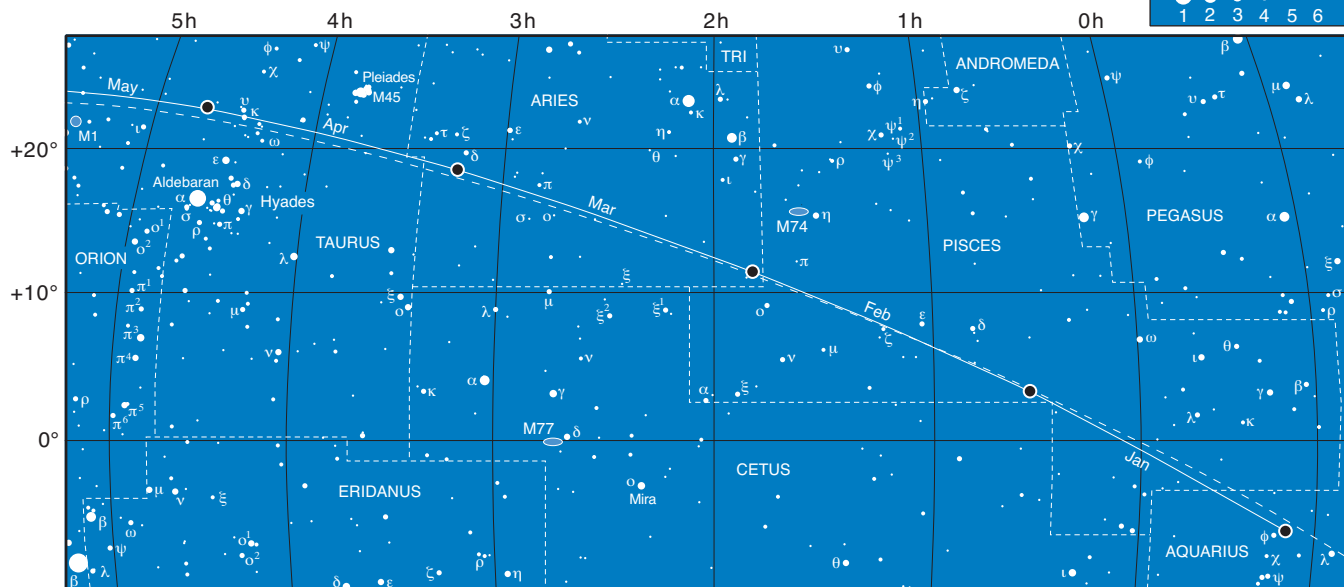
AEST (Adelaide & Darwin ACST)

POSITION

(0hrs UT Epoch 2000.0)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville		RA			DEC			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h	m	s	°	'	"	
Jan	5	10:26	22:56	10:02	22:25	10:13	22:44	11:06	23:18	10:17	22:56	10:29	23:02	10:06	22:35	10:30	22:47	23	23	26	-	04	37	01
	12	10:23	22:41	09:57	22:12	10:11	22:29	10:59	23:07	10:16	22:39	10:26	22:46	10:03	22:20	10:24	22:35	23	42	04	-	02	28	31
	19	10:20	22:26	09:53	21:58	10:08	22:14	10:52	22:56	10:15	22:22	10:24	22:31	09:59	22:05	10:18	22:23	00	00	37	-	00	19	46
	26	10:17	22:11	09:48	21:45	10:05	21:59	10:45	22:45	10:14	22:05	10:22	22:15	09:56	21:51	10:12	22:11	00	19	08	+	01	48	16
Feb	2	10:13	21:56	09:43	21:31	10:01	21:44	10:37	22:34	10:12	21:48	10:19	21:59	09:52	21:36	10:06	21:59	00	37	37	+	03	54	40
	9	10:10	21:41	09:38	21:18	09:58	21:29	10:30	22:23	10:11	21:31	10:16	21:44	09:49	21:21	09:59	21:47	00	56	08	+	05	58	38
	16	10:07	21:26	09:34	21:04	09:55	21:14	10:23	22:13	10:09	21:15	10:14	21:28	09:45	21:07	09:53	21:35	01	14	43	+	07	59	26
	23	10:03	21:12	09:29	20:51	09:52	21:00	10:16	22:02	10:08	20:59	10:11	21:13	09:42	20:52	09:47	21:23	01	33	24	+	09	56	14
Mar	2	10:00	20:58	09:24	20:39	09:48	20:45	10:09	21:52	10:06	20:42	10:08	20:58	09:38	20:38	09:41	21:12	01	52	11	+	11	48	15
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Apr	6	09:42	19:53	09:00	19:40	09:31	19:40	09:34	21:03	09:57	19:29	09:53	19:51	09:20	19:34	09:11	20:19	03	28	38	+	19	33	07
	13	09:38	19:41	08:55	19:29	09:27	19:28	09:28	20:54	09:54	19:16	09:50	19:39	09:15	19:23	09:05	20:09	03	48	28	+	20	42	49
	20	09:34	19:30	08:50	19:19	09:23	19:17	09:21	20:46	09:51	19:04	09:46	19:27	09:11	19:12	08:59	20:00	04	08	28	+	21	43	35
	27	09:29	19:20	08:45	19:10	09:18	19:07	09:15	20:37	09:48	18:53	09:42	19:17	09:06	19:02	08:53	19:51	04	28	36	+	22	35	01
May	4	09:24	19:10	08:39	19:01	09:13	18:57	09:08	20:29	09:44	18:42	09:37	19:07	09:01	18:52	08:47	19:42	04	48	50	+	23	16	47
	11	09:19	19:01	08:33	18:52	09:08	18:48	09:01	20:21	09:39	18:33	09:32	18:57	08:56	18:43	08:41	19:34	05	09	08	+	23	48	43
	18	09:13	18:53	08:27	18:44	09:02	18:40	08:54	20:14	09:33	18:24	09:26	18:49	08:50	18:35	08:34	19:26	05	29	29	+	24	10	40
	25	09:06	18:45	08:20	18:36	08:55	18:32	08:47	20:06	09:27	18:16	09:19	18:41	08:43	18:27	08:27	19:19	05	49	48	+	24	22	35
Jun	1	08:59	18:37	08:13	18:29	08:48	18:24	08:40	19:59	09:20	18:08	09:12	18:33	08:36	18:20	08:20	19:12	06	10	03	+	24	24	31
	8	08:51	18:30	08:05	18:22	08:40	18:17	08:32	19:52	09:12	18:01	09:04	18:26	08:28	18:13	08:12	19:04	06	30	11	+	24	16	37
	15	08:43	18:24	07:57	18:15	08:32	18:11	08:24	19:44	09:03	17:55	08:55	18:20	08:19	18:06	08:04	18:57	06	50	11	+	23	59	06
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Jul	6	08:13	18:06	07:28	17:55	08:01	17:53	07:58	19:22	08:30	17:39	08:25	18:03	07:50	17:48	07:37	18:36	07	48	52	+	22	12	16
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Aug	3	07:23	17:43	06:42	17:29	07:12	17:31	07:18	18:50	07:36	17:22	07:33	17:42	07:01	17:25	06:54	18:07	09	03	17	+	18	00	14
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	24	06:40	17:26	06:03	17:09	06:29	17:14	06:45	18:24	06:49	17:10	06:49	17:27	06:18	17:08	06:18	17:43	09	56	09	+	13	47	43
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Sep	7	06:10	17:15	05:35	16:55	05:58	17:02	06:21	18:06	06:15	17:01	06:18	17:16	05:48	16:55	05:52	17:27	10	30	14	+	10	37	32
	14	05:54	17:09	05:20	16:47	05:43	16:56	06:08	17:57	05:58	16:56	06:01	17:11	05:33	16:49	05:39	17:18	10	46	59	+	08	57	31
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Oct	5	05:06	16:50	04:36	16:25	04:54	16:38	05:31	17:28	05:05	16:43	05:12	16:54	04:45	16:30	04:59	16:52	11	36	30	+	03	44	17
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Nov	2	04:01	16:25	03:37	15:55	03:49	16:13	04:39	16:49	03:54	16:25	04:05	16:31	03:41	16:05	04:04	16:17	12	42	02	-	03	24	41
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	23	03:14	16:07	02:53	15:33	03:02	15:56	04:02	16:21	03:01	16:11	03:16	16:15	02:54	15:46	03:24	15:52	13	31					

MARS FINDER CHART



JUPITER

RISE AND SET TIMES

AEST (Adelaide & Darwin ACST)

POSITION

(0hrs UT Epoch 2000.0)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville		RA			DEC			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h	m	s	°	'	"	
Jan	5	19:06	04:57	18:21	04:47	18:55	04:44	18:50	06:15	19:25	04:29	19:19	04:53	18:43	04:39	18:29	05:29	06	43	56	+	23	04	00
	12	18:35	04:25	17:50	04:15	18:24	04:12	18:19	05:43	18:54	03:57	18:47	04:22	18:12	04:07	17:58	04:57	06	39	55	+	23	09	01
	19	18:04	03:53	17:19	03:44	17:53	03:41	17:48	05:12	18:23	03:26	18:16	03:50	17:41	03:36	17:27	04:25	06	36	08	+	23	13	25
	26	17:33	03:22	16:48	03:13	17:22	03:10	17:17	04:41	17:52	02:55	17:46	03:19	17:10	03:05	16:56	03:54	06	32	43	+	23	17	10
Feb	2	17:03	02:51	16:18	02:42	16:52	02:39	16:46	04:10	17:22	02:24	17:16	02:48	16:40	02:34	16:26	03:24	06	29	47	+	23	20	15
	9	16:33	02:21	15:48	02:12	16:22	02:09	16:17	03:40	16:53	01:54	16:46	02:18	16:10	02:04	15:56	02:54	06	27	26	+	23	22	43
	16	16:04	01:52	15:19	01:43	15:53	01:39	15:47	03:11	16:23	01:24	16:17	01:49	15:41	01:35	15:27	02:25	06	25	44	+	23	24	37
	23	15:36	01:23	14:50	01:14	15:25	01:11	15:19	02:43	15:55	00:56	15:48	01:20	15:13	01:06	14:58	01:56	06	24	43	+	23	26	00
Mar	2	15:08	00:56	14:23	00:46	14:57	00:43	14:51	02:15	15:27	00:28	15:21	00:52	14:45	00:38	14:30	01:28	06	24	24	+	23	26	55
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Apr	6	12:59	22:43	12:13	22:34	12:48	22:30	12:42	00:05	13:18	22:15	13:11	22:40	12:36	22:25	12:21	23:15	06	32	56	+	23	24	12
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	20	12:11	21:56	11:26	21:46	12:00	21:43	11:54	23:15	12:30	21:28	12:23	21:52	11:48	21:38	11:33	22:28	06	40	23	+	23	18	45
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May	4	11:25	21:10	10:39	21:01	11:13	20:58	11:08	22:29	11:43	20:43	11:37	21:07	11:01	20:53	10:47	21:42	06	49	36	+	23	09	53
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	15	09:11	19:03	08:27	18:52	09:00	18:50	08:57	20:19	09:29	18:37	09:23	19:00	08:48	18:45	08:35	19:33	07	24	22	+	22	17	30
	22	08:49	18:42	08:05	18:32	08:38	18:30	08:35	19:58	09:07	18:16	09:01	18:40	08:26	18:25	08:14	19:13	07	30	47	+	22	04	40
	29	08:27	18:22	07:43	18:11	08:16	18:10	08:14	19:38	08:45	17:56	08:39	18:20	08:04	18:04	07:52	18:52	07	37	17	+	21	50	41
Jul	6	08:06	18:02	07:22	17:51	07:54	17:49	07:53	19:17	08:22	17:37	08:17	17:59	07:43	17:44	07:31	18:31	07	43	51	+	21	35	34
	13	07:44	17:42	07:00	17:31	07:32	17:29	07:32	18:56	08:00	17:17	07:55	17:40	07:21	17:24	07:10	18:11	07	50	27	+	21	19	24
	20	07:22	17:22	06:38	17:10	07:11	17:09	07:10	18:36	07:38	16:57	07:33	17:20	06:59	17:04	06:48	17:50	07	57	02	+	21	02	15
	27	07:00	17:02	06:17	16:50	06:49	16:49	06:49	18:15	07:16	16:38	07:11	17:00	06:37	16:44	06:27	17:30	08	03	36	+	20	44	12
Aug	3	06:38	16:42	05:55	16:30	06:26	16:29	06:28	17:54	06:53	16:18	06:49	16:40	06:15	16:24	06:05	17:09	08	10	06	+	20	25	22
	10	06:16	16:22	05:33	16:10	06:04	16:09	06:06	17:33	06:31	15:58	06:27	16:20	05:53	16:04	05:44	16:49	08	16	31	+	20	05	51
	17	05:53	16:02	05:11	15:49	05:42	15:49	05:45	17:12	06:08	15:38	06:04	16:00	05:31	15:44	05:22	16:28	08	22	50	+	19	45	49
	24	05:31	15:41	04:49	15:28	05:19	15:29	05:23	16:51	05:45	15:19	05:42	15:40	05:08	15:23	05:00	16:07	08	29	00	+	19	25	25
	31	05:08	15:21	04:27	15:08	04:57	15:08	05:01	16:30	05:22	14:58	05:19	15:19	04:46	15:03	04:38	15:46	08	34	59	+	19	04	49
Sep	7	04:45	15:00	04:04	14:47	04:34	14:48	04:39	16:09	04:59	14:38	04:56	14:59	04:23	14:42	04:16	15:25	08	40	48	+	18	44	12
	14	04:22	14:39	03:41	14:26	04:11	14:27	04:17	15:47	04:35	14:18	04:33	14:38	04:00	14:21	03:53	15:03	08	46	22	+	18	23	47
	21	03:59	14:18	03:18	14:04	03:48	14:06	03:54	15:25	04:12	13:57	04:09	14:17	03:37	14:00	03:30	14:42	08	51	41	+	18	03	48
	28	03:35	13:57	02:55	13:42	03:24	13:44	03:32	15:03	03:48	13:36	03:46	13:56	03:13	13:38	03:07	14:20	08	56	42	+	17	44	27
Oct	5	03:12	13:35	02:31	13:20	03:00	13:22	03:08	14:40	03:24	13:14	03:22	13:34	02:49	13:16	02:44	13:57	09	01	24	+	17	26	00
	12	02:48	13:12	02:08	12:58	02:36	13:00	02:45	14:17	02:59	12:52	02:58	13:12	02:25	12:54	02:20	13:34	09	05	43	+	17	08	44
	19	02:23	12:50	01:43	12:35	02:12	12:37	02:21	13:54	02:35	12:30	02:33	12:49	02:01	12:31	01:56	13:11	09	09	39	+	16	52	54
	26	01:58	12:26	01:19	12:11	01:47	12:14	01:57	13:30	02:10	12:06	02:08	12:26	01:36	12:08	01:32	12:47	09	13	08	+	16	38	47
Nov	2	01:33	12:02	00:54	11:47	01:22	11:50	01:32	13:06	01:44	11:43	01:43	12:02	01:11	11:44	01:07	12:23	09	16	09	+	16	26	37
	9	01:08	11:38	00:28	11:22	00:56	11:25	01:07	12:41	01:19	11:18	01:17	11:37	00:46	11:19	00:42	11:58	09	18	39	+	16	16	43
	16	00:42	11:13	23:59	10:57	00:30	11:00	00:41	12:15	00:53	10:53	00:51	11:12	00:20	10:54	00:16	11:33	09	20	36	+	16	09	19
	23	00:15	10:47	23:33	10:31	00:04	10:34	00:15	11:49	00:26	10:28	00:25	10:46	23:49	10:28	23:46	11:07	09	21	58	+	16	04	36

JUPITER — LONGITUDE OF CENTRAL MERIDIAN

SYSTEM I (0hr UT)													
DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DATE
1	270.1	127.9	228.7	079.6	130.5	337.8	027.4	235.3	084.3	137.3	350.3	047.9	1
2	068.1	285.8	026.5	237.4	288.1	135.5	185.1	033.0	242.1	295.1	148.1	205.8	2
3	226.1	083.8	184.3	035.1	085.8	293.1	342.7	190.6	039.8	092.9	306.0	003.8	3
4	024.2	241.7	342.1	192.8	243.5	090.8	140.4	348.3	197.5	250.7	103.9	161.8	4
5	182.2	039.6	140.0	350.5	041.1	248.4	298.1	146.0	355.3	048.5	261.8	319.7	5
6	340.2	197.6	297.8	148.2	198.8	046.1	095.7	303.7	153.0	206.3	059.7	117.7	6
7	138.2	355.5	095.6	306.0	356.5	203.7	253.4	101.4	310.8	004.1	217.6	275.7	7
8	296.3	153.4	253.4	103.7	154.1	001.4	051.0	259.1	108.5	162.0	015.5	073.7	8
9	094.3	311.3	051.2	261.4	311.8	159.0	208.7	056.8	266.3	319.8	173.4	231.7	9
10	252.3	109.2	209.0	059.1	109.5	316.7	006.4	214.5	064.0	117.6	331.3	029.6	10
11	050.3	267.1	006.8	216.8	267.1	114.3	164.0	012.2	221.8	275.4	129.2	187.6	11
12	208.3	065.0	164.6	014.5	064.8	272.0	321.7	169.9	019.5	073.2	287.1	345.6	12
13	006.3	222.9	322.3	172.2	222.4	069.6	119.4	327.6	177.3	231.1	085.0	143.6	13
14	164.3	020.8	120.1	329.9	020.1	227.3	277.0	125.3	335.1	028.9	242.9	301.6	14
15	322.3	178.7	277.9	127.6	177.7	024.9	074.7	283.0	132.8	186.7	040.8	099.6	15
16	120.3	336.6	075.7	285.3	335.4	182.6	232.4	080.8	290.6	344.6	198.7	257.6	16
17	278.3	134.4	233.4	083.0	133.1	340.2	030.1	238.5	088.4	142.4	356.7	055.6	17
18	076.3	292.3	031.2	240.6	290.7	137.9	187.7	036.2	246.1	300.2	154.6	213.6	18
19	234.3	090.2	189.0	038.3	088.4	295.5	345.4	193.9	043.9	098.1	312.5	011.6	19
20	032.3	248.1	346.7	196.0	246.0	093.2	143.1	351.6	201.7	255.9	110.5	169.6	20
21	190.3	045.9	144.5	353.7	043.7	250.9	300.8	149.3	359.4	053.8	268.4	327.7	21
22	348.3	203.8	302.3	151.4	201.3	048.5	098.4	307.0	157.2	211.6	066.3	125.7	22
23	146.3	001.6	100.0	309.1	359.0	206.2	256.1	104.8	315.0	009.5	224.3	283.7	23
24	304.2	159.5	257.8	106.8	156.6	003.8	053.8	262.5	112.8	167.3	022.2	081.7	24
25	102.2	317.3	055.5	264.4	314.3	161.5	211.5	060.2	270.6	325.2	180.1	239.7	25
26	260.2	115.2	213.2	062.1	111.9	319.1	009.2	217.9	068.4	123.0	338.1	037.7	26
27	058.1	273.0	011.0	219.8	269.6	116.8	166.8	015.7	226.1	280.9	136.0	195.8	27
28	216.1	070.8	168.7	017.5	067.2	274.4	324.5	173.4	023.9	078.8	294.0	353.8	28
29	014.0	326.5	175.1	224.9	072.1	122.2	331.1	181.7	236.6	092.0	151.8	299.9	29
30	172.0	124.2	332.8	022.5	229.8	279.9	128.9	339.5	034.5	249.9	107.9	231.7	30
31	329.9		281.9		180.2		077.6	286.6		192.4			31

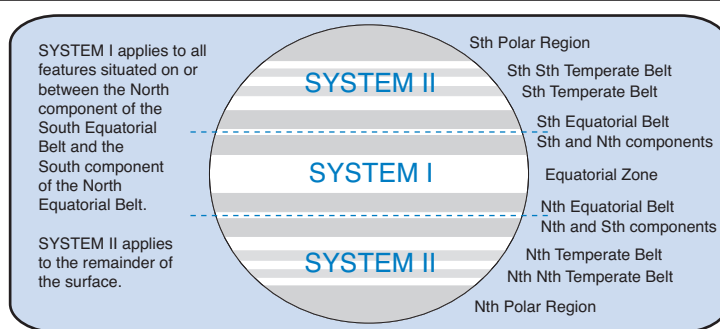
SYSTEM II (0hr UT)													
DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DATE
1	072.7	054.0	301.2	275.7	097.6	068.5	249.1	220.5	193.0	017.1	353.5	182.1	1
2	223.1	204.3	091.4	065.7	247.6	218.5	039.2	010.5	343.1	167.2	143.7	332.5	2
3	013.5	354.7	241.6	215.8	037.7	008.5	189.2	160.6	133.2	317.4	294.0	122.8	3
4	163.9	145.0	031.8	005.9	187.7	158.5	339.2	310.6	283.3	107.6	084.2	273.2	4
5	314.3	295.3	182.0	156.0	337.7	308.5	129.3	100.7	073.4	257.8	234.5	063.5	5
6	104.7	085.5	332.1	306.1	127.8	098.6	279.3	250.8	223.5	047.9	024.7	213.8	6
7	255.1	235.8	122.3	096.2	277.8	248.6	069.3	040.8	013.7	198.1	175.0	004.2	7
8	045.5	026.1	272.5	246.3	067.9	038.6	219.4	190.9	163.8	348.3	325.3	154.5	8
9	195.9	176.4	062.7	036.3	217.9	188.6	009.4	341.0	313.9	138.5	115.5	304.9	9
10	346.3	326.7	212.8	186.4	007.9	338.6	159.4	131.0	104.0	288.7	265.8	095.2	10
11	136.7	117.0	003.0	336.5	157.9	128.7	309.5	281.1	254.1	078.9	056.1	245.6	11
12	287.1	267.2	153.1	126.6	308.0	278.7	099.5	071.2	044.3	229.1	206.3	036.0	12
13	077.4	057.5	303.3	276.6	098.0	068.7	249.5	221.3	194.4	019.2	356.6	186.3	13
14	227.8	207.8	093.5	066.7	248.0	218.7	039.6	011.3	344.5	169.4	146.9	336.7	14
15	018.2	358.0	243.6	216.8	038.1	008.7	189.6	161.4	134.7	319.6	297.2	127.1	15
16	168.6	148.3	033.7	006.8	188.1	158.8	339.7	311.5	284.8	109.8	087.5	277.4	16
17	318.9	298.5	183.9	156.9	338.1	308.8	129.7	101.6	074.9	260.1	237.8	067.8	17
18	109.3	088.8	334.0	307.0	128.1	098.8	279.7	251.7	225.1	050.3	028.1	218.2	18
19	259.7	239.0	124.2	097.0	278.2	248.8	069.8	041.7	015.2	200.5	178.4	008.6	19
20	050.0	029.2	274.3	247.1	068.2	038.9	219.8	191.8	165.3	350.7	328.7	158.9	20
21	200.4	179.5	064.4	037.1	218.2	188.9	009.9	341.9	315.5	140.9	119.0	309.3	21
22	350.7	329.7	214.6	187.2	008.2	338.9	159.9	132.0	105.6	291.1	269.3	099.7	22
23	141.1	119.9	004.7	337.2	158.3	128.9	310.0	282.1	255.8	081.3	059.6	250.1	23
24	291.4	270.1	154.8	127.3	308.3	279.0	100.0	072.2	045.9	231.6	209.9	040.5	24
25	081.8	060.4	304.9	277.3	098.3	069.0	250.1	222.3	196.1	021.8	000.2	190.9	25
26	232.1	210.6	095.0	067.4	248.3	219.0	040.1	012.4	346.2	172.0	150.5	341.3	26
27	022.4	000.8	245.1	217.4	038.3	009.0	190.2	162.5	136.4	322.3	300.8	131.6	27
28	172.8	151.0	035.2	007.5	188.4	159.1	340.2	312.6	286.6	112.5	091.2	282.0	28
29	323.1	185.4	157.5	338.4	309.1	130.3	102.7	076.7	262.7	241.5	072.4	299.9	29
30	113.4	335.5	307.6	128.4	099.1	280.3	252.8	226.9	053.0	031.8	222.8	107.9	30
31	263.7		125.6		278.4		070.4	042.9		203.2			31

SYSTEM I

Rotation: 9h 50m 30.003s

hr	deg°	hr	deg°	min	deg°
01	036.6	13	115.5	05	03.0
02	073.2	14	152.1	10	06.1
03	109.7	15	188.7	15	09.1
04	146.3	16	225.3	20	12.2
05	182.9	17	261.8	25	15.2
06	219.5	18	298.4	30	18.3
07	256.1	19	335.0	35	21.3
08	292.6	20	011.6	40	24.4
09	329.2	21	048.2	45	27.4
10	005.8	22	084.7	50	30.5
11	042.4	23	121.3	55	33.5
12	079.0	24	157.9	60	36.6

Increase in longitude



For further explanation see page 73

SYSTEM II

Rotation: 9h 55m 40.062s

hr	deg°	hr	deg°	min	deg°
01	036.3	13	111.4	05	03.0
02	072.5	14	147.7	10	06.0
03	108.8	15	183.9	15	09.1
04	145.0	16	220.2	20	12.1
05	181.3	17	256.5	25	15.1
06	217.6	18	292.7	30	18.1
07	253.8	19	329.0	35	21.2
08	290.1	20	005.2	40	24.2
09	326.4	21	041.5	45	27.2
10	002.6	22	077.8	50	30.2
11	038.9	23	114.0	55	33.2
12	075.1	24	150.3	60	36.3

Increase in longitude

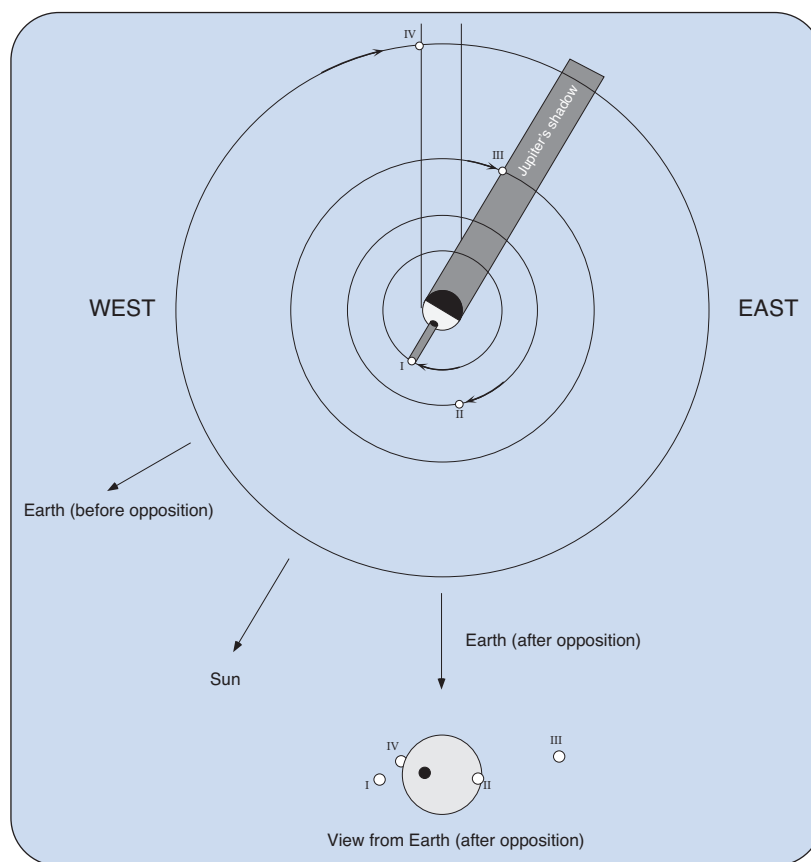
JUPITER'S MOONS 2002

Jupiter and its moons can be likened to a miniature solar system. Although there are currently 28 known Jovian satellites, most of them are too faint for amateur equipment. The four Galilean Satellites, named after their discoverer, Galileo (who suggested calling them the 'Medicean Stars'), are bright enough to be visible in small telescopes (or moderate sized binoculars). The dance of these moons, as they pass back and forth across Jupiter, is illustrated in the monthly 'Jupiter's Moons' on pages 107-109. All the moons orbit in roughly the same plane, which is very close to the Earth's orbit. Hence we see the Jovian system as edge-on. This is the key point to understanding the satellite phenomena. From our perspective on Earth, we see four types of events. They are:

- 1 The satellite passes in front of Jupiter. This is called a **Satellite Transit**.
- 2 The shadow of a satellite can move across the 'surface' of the planet. This is called a **Satellite Shadow Transit**. The start of a satellite or shadow transit is called its ingress, the finish, its egress. Before opposition, the shadow transit of a satellite will commence before that of the satellite itself. After opposition, the satellite will transit before the shadow. Jupiter's opposition date in 2002 is January 1st.
- 3 A satellite can go into **occultation** i.e., pass behind the disc of Jupiter.
- 4 A satellite can be **eclipsed** as it passes into Jupiter's shadow. The closer Jupiter is to opposition, the more likely the eclipse events, or at least one event (disappearance or reappearance) will be hidden by the planet's disc. This is especially relevant for the close-in satellites. In fact, Io is so close to Jupiter, it is impossible to see both the disappearance and reappearance for the same eclipse. Positions for the disappearance (d) and reappearance (r) for each moon, relative to Jupiter, for each month, are presented in the diagram below.

The diagram above illustrates all of the Jupiter

Note: In the tables on pages 105 to 106, some events may happen (as seen from your location) while Jupiter is just below the horizon, or while the Sun is just above the horizon. This allows for the variation in rise and set times for Jupiter and the Sun across Australia.



satellite events. It is only an example and does not represent any particular date. Viewed from the Earth (after opposition):

Satellite I's (Io) shadow is currently in transit. The satellite itself would have recently egressed from a transit.

Satellite II (Europa) has just commenced a satellite transit (ingress).

Satellite III (Ganymede) is about to be eclipsed (disappear).

Satellite IV (Callisto) is about to move out of sight as it is occulted by Jupiter's disc.

JUPITER'S MOONS Legend (pp. 105-106)

Column 1 Date & time (in AEST). Date only appears for the first event each day.

Column 2 I = Io, II = Europa, III = Ganymede, IV = Callisto

Column 3 OC = Occultation, SH = Shadow Transit, TR = Satellite Transit, EC = Eclipse

Column 4 I = Ingress, E = Egress, D = Disappearance, R = Reappearance

ECLIPSE POSITIONS OF JUPITER'S MOONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I												
II												
III												
IV												

These diagrams represent the edge of Jupiter's shadow for each moon on the 15th of each month, showing where a moon would disappear or reappear for an eclipse on that date. West to the left, east to the right.

JUPITER'S MOONS (AEST)

January				22	20:02	IV	OCR	17	19:30	I	TRI	18	17:55	II	SHI	20	18:07	I	TRI			
1	01:36	I	SHI		22:13	IV	ECD		20:30	I	SHI		18:09	II	TRE		19:20	I	SHI			
	01:37	I	TRI	23	01:11	IV	ECR		21:44	I	TRE		20:42	II	SHE		20:22	I	TRE			
	03:51	I	SHE						22:45	I	SHE	19	21:24	I	TRI		21:35	I	SHE			
	03:52	I	TRE	24	01:15	I	TRI	18	20:07	I	ECR		22:40	I	SHI	21	18:55	I	ECR			
	20:17	III	TRI		01:48	I	SHI															
	20:18	III	SHI		22:34	I	OCR	19	23:31	II	OCR	20	18:44	I	OCR	22	17:27	III	OCR			
	22:55	I	OCR	25	01:24	I	ECR	20	20:00	III	TRI		22:17	I	ECR		20:37	III	OCR			
	23:19	III	TRE		19:41	I	TRI		23:02	III	TRE	21	18:07	I	TRE	24	19:27	IV	TRE			
23:21	III	SHE		20:17	I	SHI	21	00:16	III	SHI		19:24	I	SHE	26	17:52	II	TRI				
2	01:11	I	ECR		21:56	I	TRE		18:39	II	TRI	22	18:36	IV	SHE		20:11	II	SHI			
	01:11	III	SHI	26	22:32	I	SHE		20:47	II	SHI					20:39	II	TRE				
	01:11	II	ECD		19:49	III	OCR	24	21:25	II	TRE	23	22:48	II	OCR	27	20:06	I	TRI			
	20:03	I	TRI		19:53	I	ECR		23:35	II	SHE											
	20:05	I	SHI	27	01:26	III	ECR	25	00:11	I	OCR	25	17:57	II	TRI	28	17:24	I	OCR			
	22:17	I	TRE		22:22	II	TRI		21:19	I	TRI		20:31	II	SHI		17:26	II	ECR			
22:19	I	SHE		23:40	II	SHI	24	22:25	I	SHI		20:43	II	TRE		20:50	I	ECR				
3	02:26	II	TRI	28	01:10	II	TRE		23:33	I	TRE	27	17:34	II	ECR	29	16:51	I	TRE			
	02:31	II	SHI		02:28	II	SHE		23:53	IV	OCR		20:38	I	OCR		18:00	I	SHE			
	19:40	I	ECR	29	20:38	II	ECR	25	00:40	I	SHE	28	17:47	I	TRI	May						
4	20:36	II	OCR	31	02:29	IV	TRI		18:39	I	OCR		18:09	III	TRE	3	19:33	III	SHE			
	23:33	II	ECR						22:02	I	ECR		19:05	I	SHI		20:35	II	TRI			
6	03:08	IV	OCR	February				26	19:09	I	SHE		20:02	I	TRE	5	19:23	I	OCR			
8	03:20	I	TRI	1	00:20	I	OCR	27	23:40	III	TRI		20:15	III	SHI		20:04	II	ECR			
	03:30	I	SHI		21:27	I	TRI	28	21:05	II	TRI	29	21:20	I	SHE	6	17:40	I	SHI			
	23:33	III	TRI		22:11	I	SHI		23:24	II	SHI			21:00	I		SHI	18:50	I	TRE		
	9	00:18	III	SHI		23:42	I	TRE		23:52	II		TRE		21:58	I	TRE	19:56	I	SHE		
00:39		I	OCR	2	00:26	I	SHE	March					April				7	17:13	I	ECR		
02:35		III	TRE		18:46	I	OCR	2	20:23	II	ECR	1	20:33	II	TRI	10		19:17	III	TRE		
03:06		I	ECR		21:48	I	ECR					3	20:12	II	ECR		20:16	III	SHI			
03:22		III	SHE		23:14	III	OCR	3	18:18	III	ECD		22:34	I	OCR	12	17:44	II	OCR			
21:46	I	TRI	3	02:17	III	OCR		21:30	III	ECR	4	19:07	III	TRI	13	18:35	I	TRI				
21:59	I	SHI		02:19	III	ECD		23:10	I	TRI			19:43	I		TRI	19:35	I	SHI			
10	00:01	I	TRE		18:55	I	SHE	4	00:21	I		SHI		21:00	I	SHI	14	17:27	II	SHE		
	00:14	I	SHE	4	00:41	II	TRI		20:30	I	OCR		21:58	I	TRE	19:08		I	ECR			
	19:05	I	OCR		02:16	II	SHI	4	23:57	I	ECR		22:12	III	TRE	19	19:49	IV	OCR			
	21:34	I	ECR	5	18:47	II	OCR	5	18:49	I	SHI	5	20:36	I	ECR		21	17:14	II	SHI		
11	18:42	I	SHE		23:14	II	ECR		19:52	I	TRE	6	17:44	I	SHE	21	17:39	III	ECR			
	22:49	II	OCR	6	19:22	III	SHE		21:04	I	SHE	7	21:19	IV	TRI		17:52	I	OCR			
12	02:08	II	ECR	8	02:07	I	OCR	6	21:04	IV	SHI	8	17:35	III	ECR		18:14	II	TRE			
	13	20:36	II	TRE		19:24	IV	ECR	6	18:26	I	ECR	10	17:23	II		OCR	22	17:21	I	TRE	
21:15		II	SHE		23:14	I	TRI								18:16	I	SHE					
16		02:23	I	OCR	9	00:06	I	SHI	7	23:35	II	TRI	11	21:40	I	TRI	28	18:12	II	TRI		
		02:49	III	TRI		01:28	I	TRE	9	23:01	II	ECR	12	17:47	II	SHE		18:15	III	OCR		
	23:30	I	TRI		20:33	I	OCR	10	20:24	III	OCR		18:59	I	OCR	18:17		III	ECD			
	23:53	I	SHI		23:43	I	ECR		22:19	III	ECD	13	17:24	I	SHI	19:15		IV	SHE			
17	01:45	I	TRE	10	18:35	I	SHI	11	18:06	II	SHE	15	18:19	III	ECD	29	17:06	I	TRI			
	02:08	I	SHE		19:55	I	TRE		22:22	I	OCR			18:24	I		TRE	17:54	I	SHI		
	20:49	I	OCR		20:50	I	SHE	12	19:30	I	TRI			19:40	I		SHE	19:22	I	TRE		
	23:29	I	ECR	12	21:08	II	OCR	12	20:45	I	SHI		16	20:13	IV		ECR	30	17:17	II	ECR	
18	20:11	I	TRE	13	19:27	III	TRE		21:45	I	TRE	17	20:05	II	OCR	5	19:07		I	TRI		
	20:37	I	SHE		20:16	III	SHI	13	23:00	I	SHE	19	17:36	II	SHI		6		16:23	I	OCR	
	19	01:04	II	OCR		23:23	III	SHE											17:57	II	TRE	7
21:25		III	ECR	14	19:01	II	TRE	16	20:13	II	OCR		20:23	II	SHE	20:57		I	OCR			
20		20:05	II	TRI		20:59	II	SHE	17	21:09	III	OCR		20:57	I	OCR						
	21:03	II	SHI	16	01:02	I	TRI															
	22:52	II	TRE		20:28	IV	TRE															
23:51	II	SHE		22:22	I	OCR																

JUPITER'S MOONS (AEST)																														
13	18:23	I	OCD	September					19	05:08	I	ECD	19	01:33	II	TRI	13	01:48	I	ECD										
	18:26	II	OCD											05:25	III	ECR		01:54	II	SHE		22:59	II	SHE						
14	17:55	I	TR E						3	04:50	I	ECD	20	02:29	I	SHI		04:26	II	TR E		23:06	I	SHI						
	18:31	I	SHE						4	05:11	I	TR E		03:41	I	TRI		04:30	I	SHI	14	00:08	I	TRI						
15	17:05	II	SHE						11	04:53	I	TRI		04:46	I	SHE	20	01:39	I	ECD		01:07	II	TR E						
	17:19	III	TR E		06:21	I	SHE	21	03:08	I	OCR	21	00:12	I	TRI		01:22	I	SHE											
21	17:40	I	TRI	12	04:19	I	OCR	25	01:57	II	SHI		01:15	I	SHE		02:24	I	TR E											
	18:09	I	SHI	13	06:00	III	ECD		04:26	II	TRI		02:28	I	TR E		23:38	I	OCR											
22	16:24	IV	OCR	14	05:35	II	ECD	27	01:36	IV	TR E	24	01:18	III	ECR	16	00:41	IV	TRI											
	16:40	IV	ECD	16	04:22	II	TR E		04:49	II	SHE		02:41	III	OCD	18	23:35	III	SHI											
	16:50	II	SHI	18	05:58	I	SHI	28	01:30	I	ECD	26	01:37	II	SHI	19	03:09	III	SHE											
	17:38	I	ECR	19	06:19	I	OCR		04:23	I	SHI		04:05	II	TRI		03:30	III	TRI											
29	16:56	I	OCD	23	04:15	II	TRI	29	01:30	I	ECD		04:30	II	SHE		04:13	II	ECD											
30	16:30	I	TR E		05:11	II	SHE	30	05:03	I	OCR	27	03:32	I	ECD	20	03:42	I	ECD											
	16:49	I	SHE	24	03:31	III	SHE		02:21	I	TR E	28	00:52	I	SHI		22:41	II	SHI											
July					03:57	III	TRI	30	04:27	III	TR E		01:49	II	OCR	21	00:37	II	TRI											
				26	04:59	I	ECD	November						02:03	I	TRI		00:59	I	SHI										
				27	03:21	I	TRI						1	04:32	II	SHI		03:08	I	SHE		01:35	II	SHE						
					04:37	I	SHE						3	05:00	II	OCR		04:19	I	TR E		01:55	I	TRI						
					05:37	I	TR E						4	03:23	I	ECD	29	01:32	I	OCR		03:16	I	SHE						
18	07:17	I	TRI	30	04:54	II	SHI							04:51	IV	OCD		01:53	IV	SHE		03:31	II	TR E						
	07:19	I	SHI	October				December									04:11	I	TR E		04:11	I	TR E							
August																														
																22	01:25	I	OCR	22	01:25	I	OCR							
																	22:11	II	OCR		22:11	II	OCR							
																	22:38	I	TR E		22:38	I	TR E							
				6	06:45	II	OCR	23	22:45	IV	ECD	23	22:45	IV	ECD															
12	06:49	IV	OCR	24	03:36	IV	ECR	24	03:36	IV	ECR																			
13	05:55	II	ECD	26	03:33	III	SHI	26	03:33	III	SHI																			
18	06:34	I	ECD	28	01:18	II	SHI	28	01:18	II	SHI																			
19	06:05	III	TRI		02:52	I	SHI		02:52	I	SHI																			
	06:11	I	SHE		03:41	I	TRI		03:41	I	TRI																			
	06:40	I	TR E		04:12	II	SHE		04:12	II	SHE																			
22	05:34	II	SHE		05:09	I	SHE		05:09	I	SHE																			
	06:37	II	TR E	29	00:04	I	ECD	29	00:04	I	ECD																			
26	05:48	I	SHI		03:12	I	OCR		03:12	I	OCR																			
	06:24	I	TRI		22:07	I	TRI		22:07	I	TRI																			
27	05:50	I	OCR		23:37	I	SHE		23:37	I	SHE																			
29	05:17	II	SHI	30	00:24	I	TR E	30	00:24	I	TR E																			
	06:33	II	TRI		00:25	III	OCR		00:25	III	OCR																			
					00:29	II	OCR		00:29	II	OCR																			
					21:38	I	OCR		21:38	I	OCR																			

Mutual Events (AEST) (see page 73)																	
Date	Start	End	Dur	Event	Type	Mag Drop	Jup Dist	Sat Sep	Date	Start	End	Dur	Event	Type	Mag Drop	Jup Dist	Sat Sep
Nov 08	02:37	02:43	00:06	II Oc I	P	0.34	5.4	0.2	Dec 17	01:31	01:41	00:09	II Ec I	A	0.63	5.7	26.0
Nov 15	04:57	05:03	00:06	II Oc I	P	0.23	5.6	0.4	Dec 23	02:47	03:53	01:06	II Oc III	P	0.18	4.4	0.5
Nov 29	03:45	03:51	00:05	IV Oc I	P	0.56	2.9	0.3	Dec 24	04:02	04:13	00:11	II Ec I	A	0.66	5.8	22.0
Dec 07	23:02	23:20	00:17	I Oc IV	A	0.19	2.2	0.1	Dec 24	23:15	23:38	00:22	II Oc I	P	0.08	5.3	0.7
Dec 09	23:05	23:14	00:08	II Ec I	P	0.52	5.5	29.6	Dec 25	22:04	22:10	00:06	III Oc I	P	0.06	5.7	1.1

The mutual events table above has the following information:

Date of the event (month and day)

Start, end and **duration** times of the events (hh:mm).

Event description e.g., II Oc I. This means satellite II occults (passes in front of) satellite I (see p. 104 for satellite number).

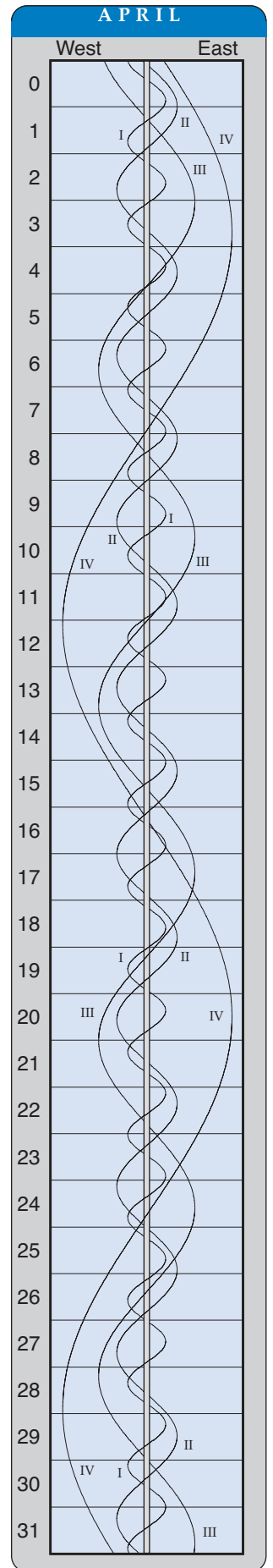
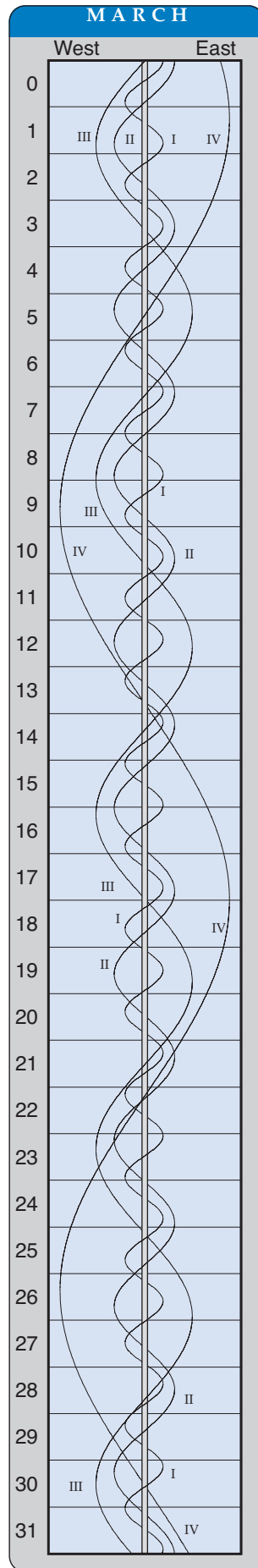
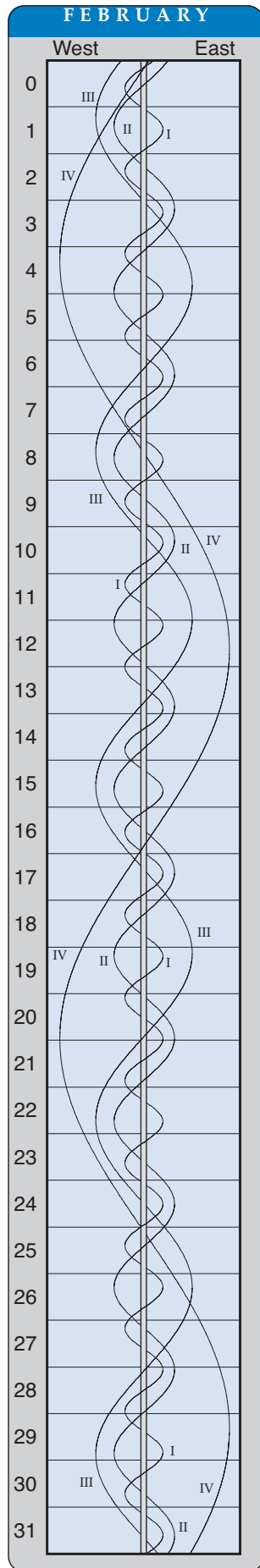
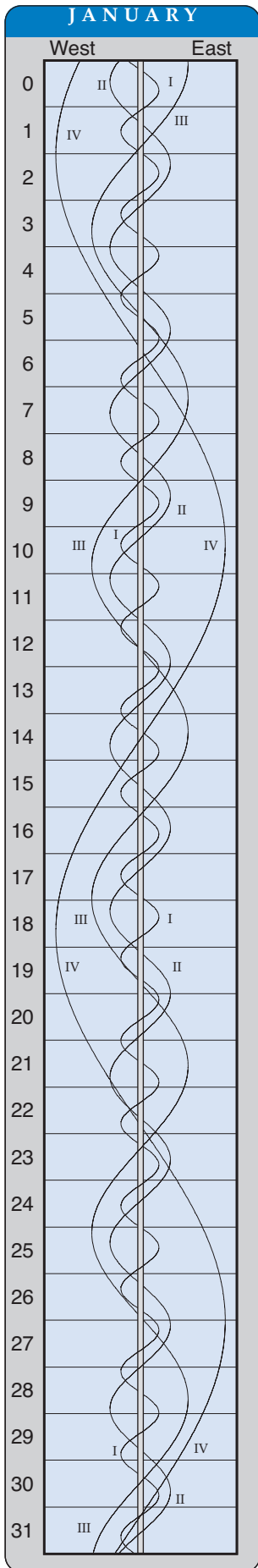
Event **type** where 'P' is partial, 'A' is annular.

Mag Drop is the maximum drop in magnitude at mid event.

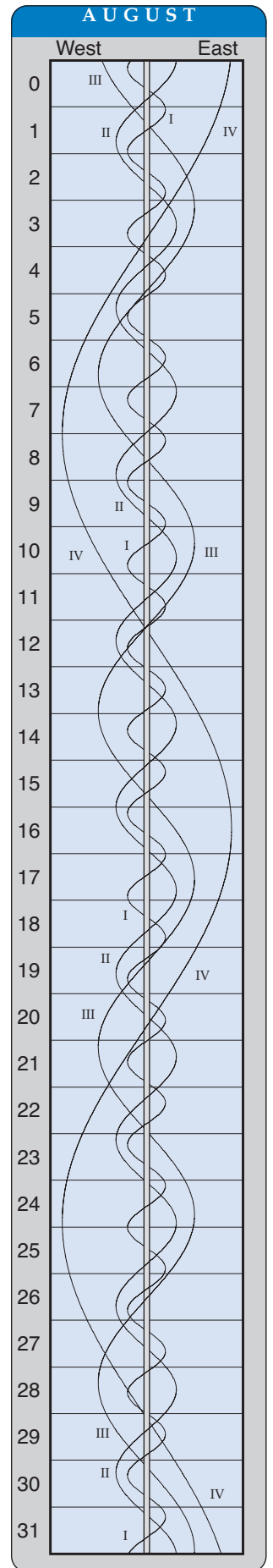
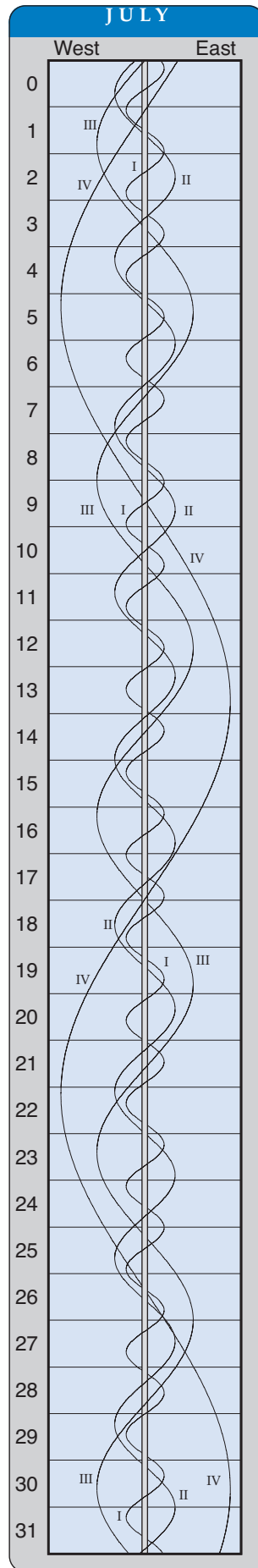
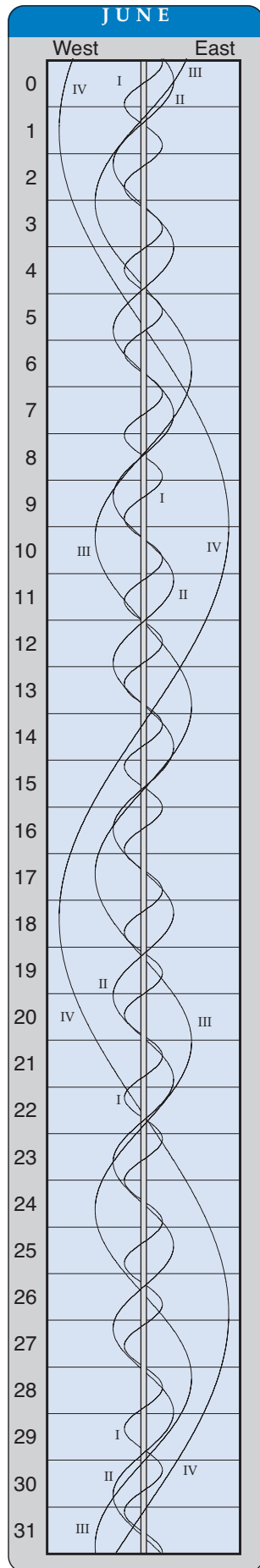
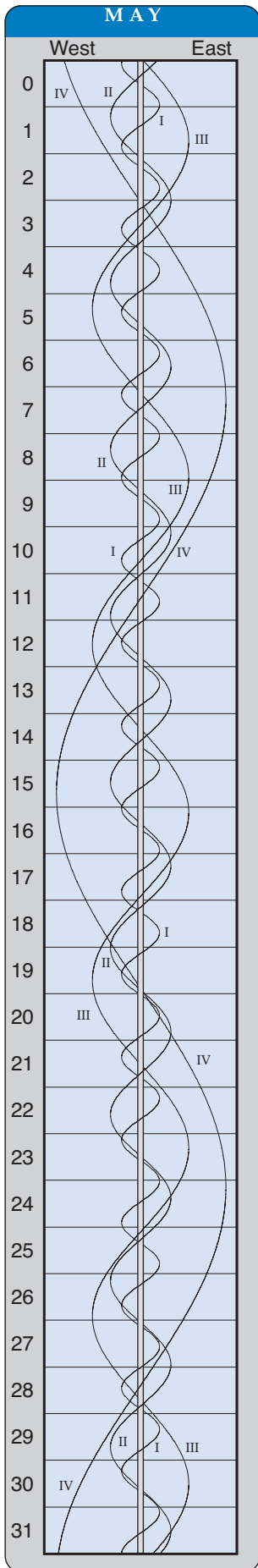
Jup Dist is the distance from Jupiter's centre (in Jupiter radii).

Sat Sep is the separation between the two satellites in arc seconds at closest approach.

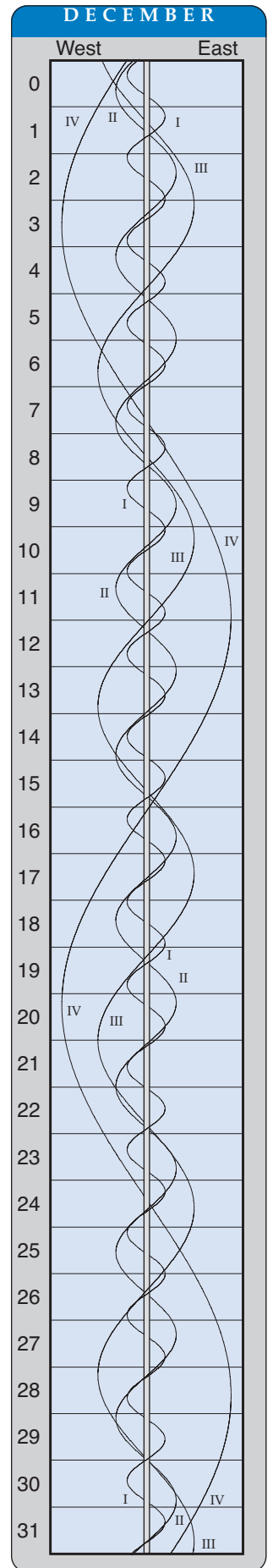
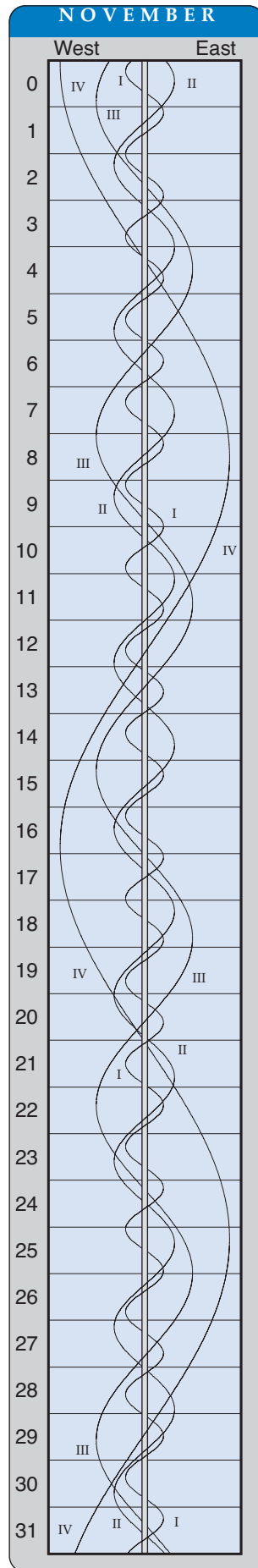
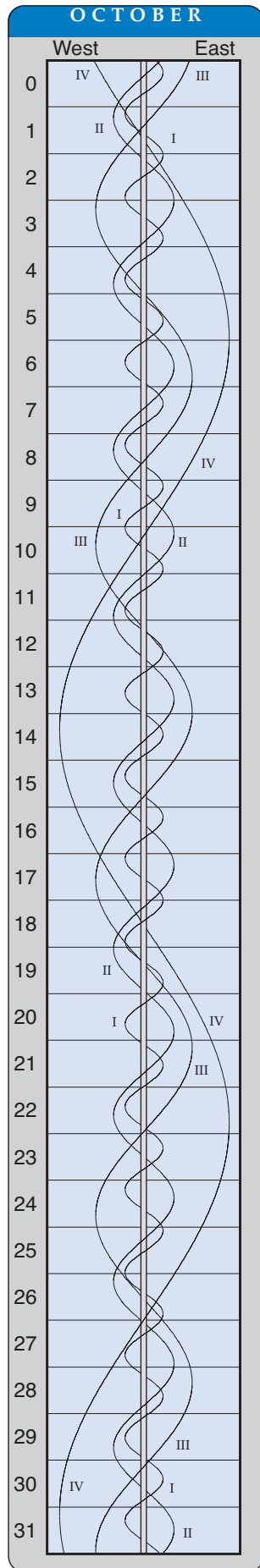
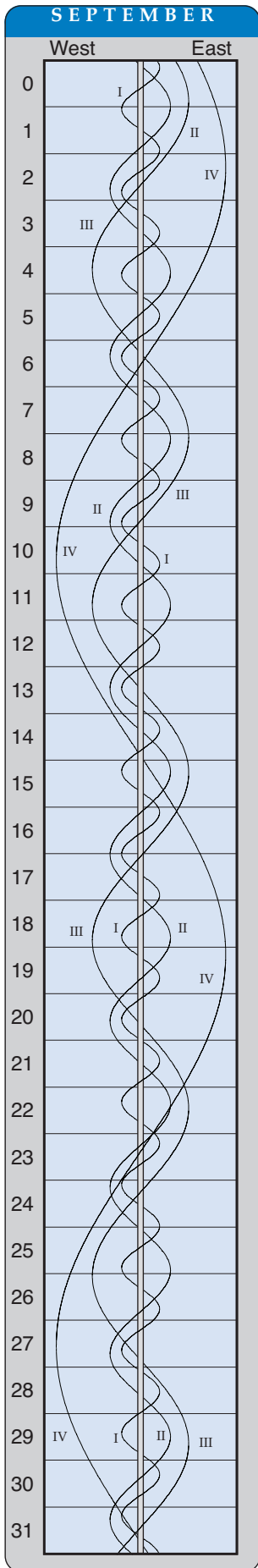
JUPITER'S MOONS (AEST)



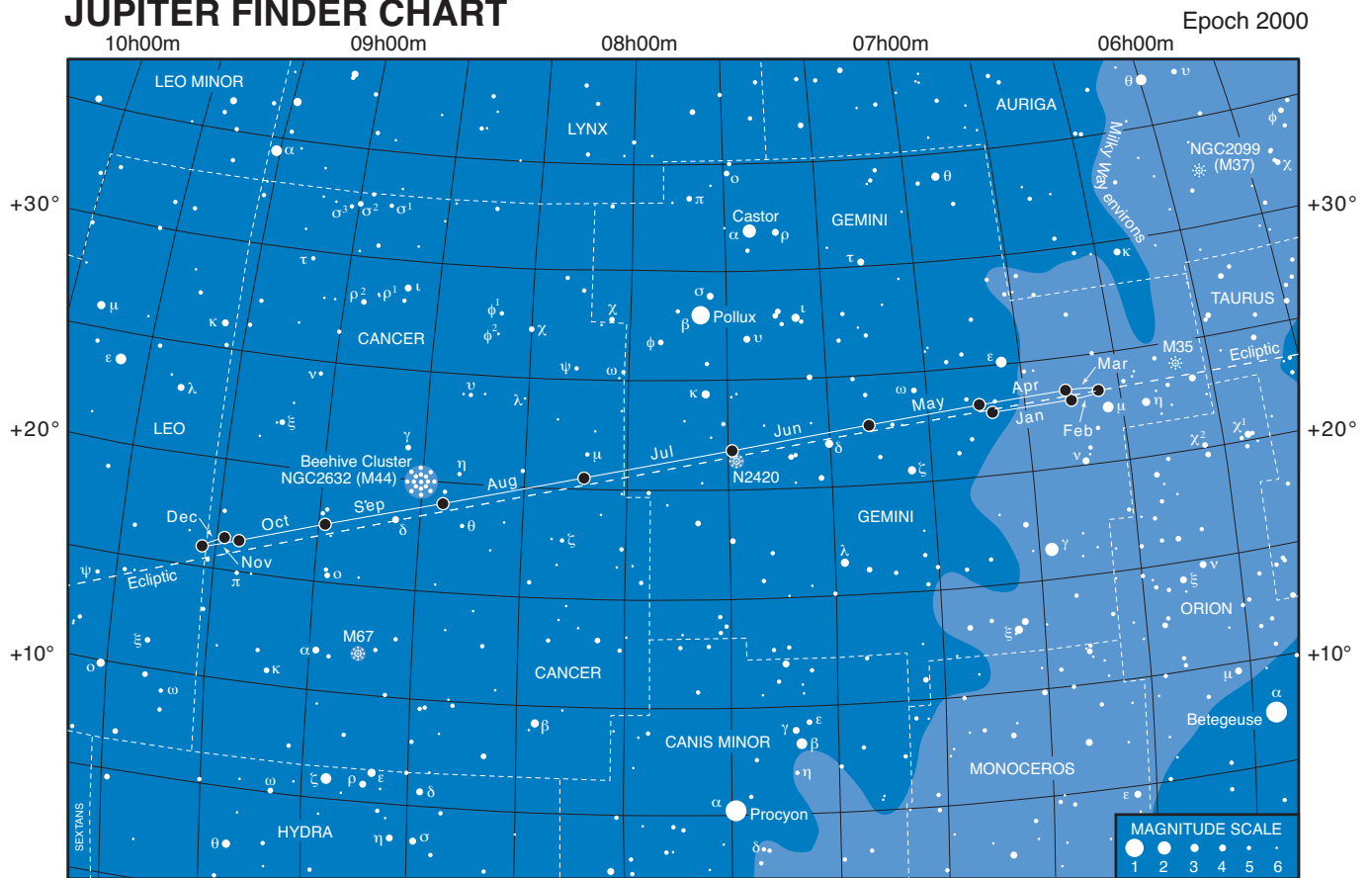
JUPITER'S MOONS (AEST)



JUPITER'S MOONS (AEST)

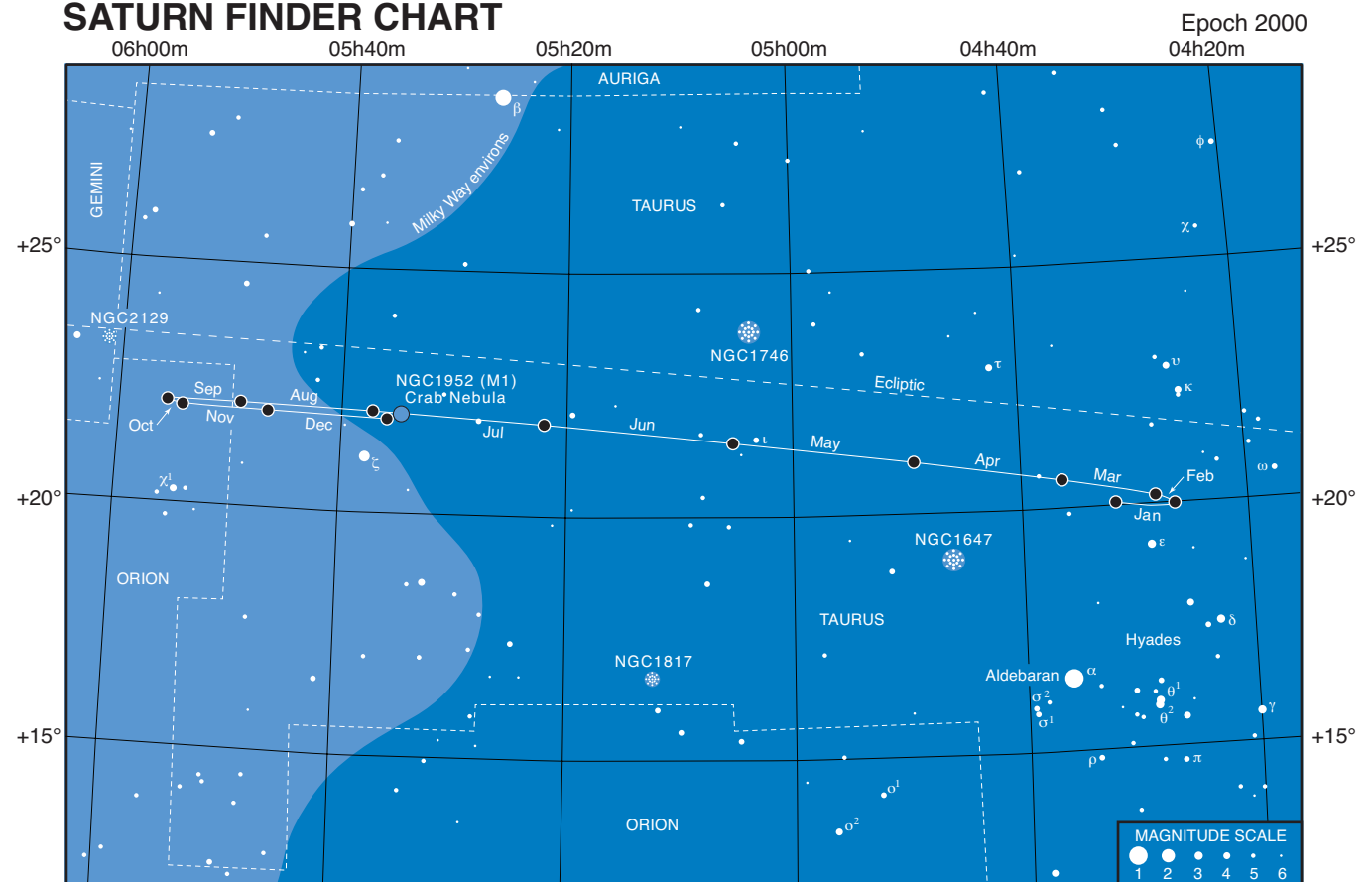


JUPITER FINDER CHART



Opposition 1st January, Stationary 2nd March, Conjunction 20th July, Stationary 5th December.

SATURN FINDER CHART



Stationary 8th February, Conjunction 9th June, Stationary 11th October, Opposition 18th December.

SATURN

RISE AND SET TIMES

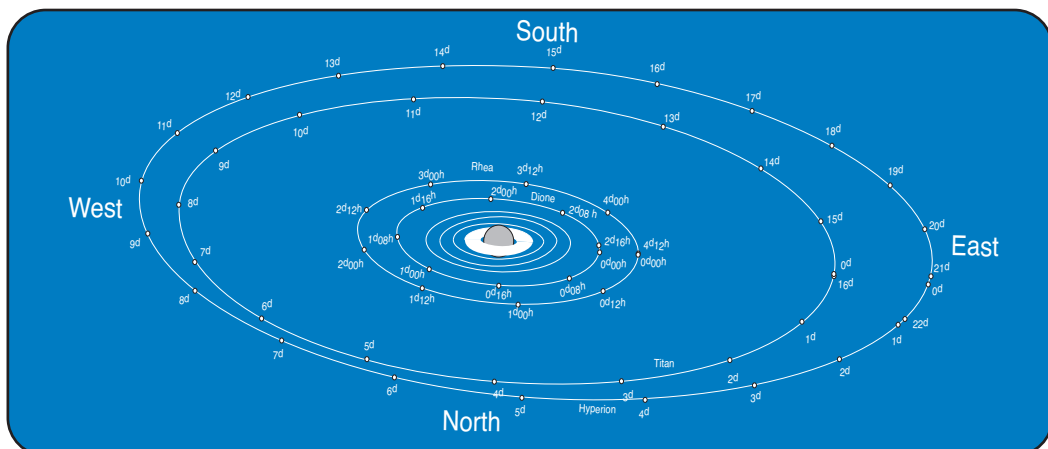
AEST (Adelaide & Darwin ACST)

POSITION

(0hrs UT Epoch 2000.0)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville		RA			DEC			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h	m	s	°	'	"	
Jan	5	16:43	02:54	16:01	02:41	16:32	02:41	16:34	04:05	16:58	02:30	16:54	02:52	16:21	02:36	16:11	03:20	04	30	34	+	20	02	08
	12	16:14	02:25	15:32	02:12	16:03	02:12	16:05	03:36	16:29	02:01	16:25	02:23	15:51	02:07	15:42	02:51	04	28	59	+	20	00	12
	19	15:45	01:56	15:03	01:43	15:34	01:43	15:36	03:07	16:00	01:32	15:56	01:54	15:23	01:38	15:14	02:22	04	27	42	+	19	59	03
	26	15:17	01:27	14:34	01:15	15:06	01:15	15:08	02:39	15:32	01:04	15:28	01:25	14:54	01:09	14:45	01:54	04	26	47	+	19	58	44
Feb	2	14:49	00:59	14:06	00:47	14:38	00:47	14:40	02:10	15:04	00:36	15:00	00:57	14:26	00:41	14:17	01:26	04	26	15	+	19	59	18
	9	14:21	00:32	13:39	00:19	14:10	00:19	14:12	01:43	14:36	00:08	14:32	00:30	13:59	00:13	13:49	00:58	04	26	05	+	20	00	45
	16	13:54	00:04	13:12	23:48	13:43	23:48	13:45	01:15	14:09	23:37	14:05	23:58	13:31	23:42	13:22	00:31	04	26	19	+	20	03	06
	23	13:27	23:33	12:45	23:21	13:16	23:21	13:18	00:48	13:43	23:09	13:39	23:31	13:05	23:15	12:55	00:04	04	26	56	+	20	06	18
Mar	2	13:01	23:06	12:18	22:54	12:50	22:54	12:52	00:22	13:16	22:43	13:12	23:04	12:38	22:48	12:29	23:33	04	27	55	+	20	10	18
	9	12:35	22:40	11:53	22:28	12:24	22:27	12:26	23:52	12:50	22:16	12:46	22:38	12:12	22:22	12:03	23:07	04	29	16	+	20	15	01
	16	12:10	22:14	11:27	22:02	11:58	22:01	12:00	23:26	12:25	21:50	12:21	22:12	11:47	21:56	11:37	22:41	04	30	58	+	20	20	22
	23	11:44	21:48	11:02	21:36	11:33	21:36	11:34	23:00	12:00	21:24	11:56	21:46	11:22	21:30	11:12	22:15	04	33	00	+	20	26	15
	30	11:20	21:23	10:37	21:11	11:08	21:10	11:09	22:35	11:35	20:58	11:31	21:20	10:57	21:05	10:47	21:50	04	35	19	+	20	32	34
Apr	6	10:55	20:57	10:12	20:45	10:44	20:45	10:45	22:10	11:11	20:33	11:06	20:55	10:32	20:39	10:22	21:25	04	37	55	+	20	39	13
	13	10:31	20:32	09:48	20:20	10:19	20:20	10:20	21:45	10:47	20:08	10:42	20:30	10:08	20:14	09:58	21:00	04	40	46	+	20	46	05
	20	10:07	20:07	09:23	19:56	09:55	19:55	09:56	21:21	10:23	19:43	10:18	20:05	09:44	19:49	09:33	20:36	04	43	51	+	20	53	04
	27	09:43	19:43	08:59	19:31	09:31	19:30	09:31	20:56	09:59	19:18	09:54	19:40	09:20	19:25	09:09	20:11	04	47	07	+	21	00	05
May	4	09:19	19:18	08:36	19:07	09:08	19:06	09:07	20:32	09:35	18:53	09:31	19:16	08:56	19:00	08:45	19:47	04	50	33	+	21	07	01
	11	08:55	18:54	08:12	18:43	08:44	18:41	08:44	20:08	09:12	18:29	09:07	18:52	08:33	18:36	08:21	19:23	04	54	08	+	21	13	48
	18	08:32	18:30	07:48	18:19	08:21	18:17	08:20	19:44	08:49	18:05	08:44	18:27	08:09	18:12	07:58	18:59	04	57	50	+	21	20	21
	25	08:08	18:06	07:25	17:55	07:57	17:53	07:56	19:20	08:25	17:40	08:20	18:03	07:46	17:48	07:34	18:35	05	01	37	+	21	26	37
Jun	1	07:45	17:42	07:01	17:31	07:34	17:29	07:33	18:56	08:02	17:16	07:57	17:39	07:22	17:24	07:11	18:11	05	05	28	+	21	32	30
	8	07:22	17:18	06:38	17:07	07:11	17:05	07:09	18:33	07:39	16:52	07:34	17:15	06:59	17:00	06:47	17:47	05	09	21	+	21	38	00
	15	06:58	16:54	06:14	16:43	06:47	16:41	06:45	18:09	07:15	16:28	07:10	16:51	06:35	16:36	06:24	17:23	05	13	15	+	21	43	03
	22	06:35	16:30	05:51	16:19	06:24	16:17	06:22	17:45	06:52	16:04	06:47	16:27	06:12	16:12	06:00	17:00	05	17	08	+	21	47	39
	29	06:11	16:06	05:27	15:55	06:00	15:53	05:58	17:21	06:29	15:40	06:23	16:03	05:49	15:48	05:37	16:36	05	20	58	+	21	51	44
Jul	6	05:48	15:42	05:04	15:31	05:37	15:29	05:35	16:58	06:05	15:16	06:00	15:39	05:25	15:24	05:13	16:12	05	24	44	+	21	55	21
	13	05:24	15:18	04:40	15:07	05:13	15:05	05:11	16:34	05:42	14:52	05:36	15:15	05:01	15:00	04:49	15:48	05	28	25	+	21	58	27
	20	05:00	14:54	04:16	14:43	04:49	14:41	04:47	16:10	05:18	14:28	05:12	14:51	04:37	14:36	04:25	15:24	05	31	58	+	22	01	05
	27	04:36	14:30	03:52	14:19	04:25	14:17	04:23	15:45	04:54	14:04	04:48	14:27	04:13	14:12	04:01	15:00	05	35	23	+	22	03	14
Aug	3	04:12	14:05	03:28	13:55	04:01	13:53	03:58	15:21	04:30	13:39	04:24	14:02	03:49	13:47	03:37	14:35	05	38	37	+	22	04	57
	10	03:48	13:41	03:04	13:30	03:37	13:28	03:34	14:57	04:05	13:14	04:00	13:38	03:25	13:23	03:12	14:11	05	41	40	+	22	06	16
	17	03:23	13:16	02:39	13:05	03:12	13:03	03:09	14:32	03:41	12:50	03:35	13:13	03:00	12:58	02:48	13:46	05	44	28	+	22	07	13
	24	02:58	12:51	02:14	12:40	02:47	12:38	02:44	14:07	03:16	12:25	03:10	12:48	02:35	12:33	02:23	13:21	05	47	02	+	22	07	50
	31	02:33	12:25	01:49	12:15	02:22	12:13	02:19	13:42	02:51	11:59	02:45	12:23	02:10	12:08	01:58	12:56	05	49	19	+	22	08	10
Sep	7	02:07	12:00	01:23	11:49	01:56	11:47	01:54	13:16	02:25	11:34	02:19	11:57	01:45	11:42	01:32	12:30	05	51	17	+	22	08	17
	14	01:42	11:34	00:57	11:24	01:30	11:21	01:28	12:50	01:59	11:08	01:54	11:31	01:19	11:16	01:06	12:04	05	52	56	+	22	08	12
	21	01:15	11:08	00:31	10:57	01:04	10:55	01:01	12:24	01:33	10:42	01:27	11:05	00:52	10:50	00:40	11:38	05	54	14	+	22	08	00
	28	00:49	10:41	00:05	10:31	00:38	10:29	00:35	11:57	01:06	10:15	01:01	10:38	00:26	10:24	00:13	11:11	05	55	10	+	22	07	42
Oct	5	00:22	10:14	23:34	10:04	00:11	10:02	00:08	11:30	00:39	09:48	00:34	10:12	23:55	09:57	23:43	10:45	05	55	44	+	22	07	21
	12	23:51	09:47	23:06	09:36	23:39	09:34	23:37	11:03	00:12	09:21	00:06	09:44	23:28	09:29	23:15	10:17	05	55	54	+	22	06	58
	19	23:23	09:19	22:38	09:09	23:12	09:07	23:09	10:35	23:40	08:53	23:35	09:16	23:00	09:02	22:47	09:49	05	55	40	+	22	06	34
	26	22:55	08:51	22:10	08:41	22:43	08:39	22:41	10:07	23:12	08:25	23:07	08:48	22:32	08:33	22:19	09:21	05	55	04	+	22	06	12
Nov	2	22:26	08:23	21:42	08:12	22:15	08:10	22:12	09:39	22:44	07:57	22:38	08:20	22:03	08:05	21:51	08:53	05	54	04	+	22	05	49
	9	21:57	07:54	21:13	07:43	21:46	07:41	21:43	09:10	22:15	07:28	22:09	07:51	21:34	07:36	21:22	08:24	05	52	44	+	22	05	27
	16	21:28	07:25	20:44	07:14	21:17	07:12	21:14	08:41	21:45	06:59	21:40	07:22	21:05	07:07	20:53	07:55	05	51	04	+	22	05	05
	23	20:58	06:55	20:14	06:45	20:47	06:43	20:45	08:11	21:16	06:29	21:10	06:53	20:35	06:38	20:23	07:25	05	49</					

SATELLITES OF SATURN



For more information
see page 73.

Satellite	Mean Synodic Period d hh.h
I Mimas	0 22.6
II Enceladus	1 08.9
III Tethys	1 21.3
IV Dione	2 17.7
V Rhea	4 12.5
VI Titan	15 23.3
VII Hyperion	21 07.6
VIII Iapetus	79 22.1
IX Phoebe	523 15.6

Apparent Orbits Diagram (at date of opposition, December 18).

Only the inner satellites are shown. The orbits of Iapetus and Phoebe are too large to show on the above diagram.

TITAN (AEST) Mean Synodic Period 15d 23.3h

Greatest Eastern Elongation	Inferior Conjunction	Greatest Western Elongation	Superior Conjunction
Jan 5 09.1	Jan 9 11.8	Jan 13 07.6	Jan 1 06.1
Jan 21 06.9	Jan 25 09.8	Jan 29 05.7	Jan 17 03.8
Feb 6 05.2	Feb 10 08.3	Feb 14 04.4	Feb 2 02.0
Feb 22 04.2	Feb 26 07.3	Mar 2 03.6	Feb 18 00.8
Mar 10 03.7	Mar 14 06.9	Mar 18 03.2	Mar 6 00.1
Mar 26 03.7	Mar 30 07.0	Apr 3 03.3	Mar 22 00.0
Apr 11 04.2	Apr 15 07.5	Apr 19 03.8	Apr 7 00.3
Apr 27 05.0	May 1 08.2	May 5 04.5	Apr 23 00.9
May 13 06.1	May 17 09.2	May 21 05.5	May 9 01.9
May 29 07.4	Jun 2 10.4	Jun 6 06.5	May 25 03.0
Jun 14 08.7	Jun 18 11.5	Jun 22 07.5	Jun 10 04.1
Jun 30 10.0	Jul 4 12.6	Jul 8 08.5	Jun 26 05.3
Jul 16 11.1	Jul 20 13.5	Jul 24 09.3	Jul 12 06.4
Aug 1 12.0	Aug 5 14.2	Aug 9 09.8	Jul 28 07.3
Aug 17 12.7	Aug 21 14.6	Aug 25 10.1	Aug 13 08.0
Sep 2 12.9	Sep 6 14.6	Sep 10 10.0	Aug 29 08.2
Sep 18 12.6	Sep 22 14.1	Sep 26 09.4	Sep 14 08.1
Oct 4 11.9	Oct 8 13.2	Oct 12 08.3	Sep 30 07.4
Oct 20 10.5	Oct 24 11.7	Oct 28 06.7	Oct 16 06.2
Nov 5 08.6	Nov 9 09.7	Nov 13 04.6	Nov 1 04.5
Nov 21 06.1	Nov 25 07.2	Nov 29 02.1	Nov 17 02.2
Dec 7 03.3	Dec 11 04.5	Dec 14 23.4	Dec 2 23.5
Dec 23 00.4	Dec 27 01.6	Dec 30 20.6	Dec 18 20.7

IAPETUS (AEST) Mean Synodic Period 79d 22.1h

Greatest Eastern Elongation	Inferior Conjunction	Greatest Western Elongation	Superior Conjunction
Feb 19 22.6	Mar 12 23.3	Jan 12 03.2	Jan 30 20.9
May 11 20.5	Jun 2 06.5	Apr 1 20.5	Apr 21 03.6
Aug 1 13.8	Aug 22 17.6	Jun 22 05.9	Jul 11 17.2
Oct 20 20.7	Nov 10 08.9	Sep 11 07.1	Sep 30 10.8
		Nov 29 09.1	Dec 18 01.1

HYPERION (AEST) Mean Synodic Period 21d 7.6h

Greatest Eastern Elongation	Inferior Conjunction	Greatest Western Elongation	Superior Conjunction
Jan 21 11.0	Jan 6 03.7	Jan 10 12.1	Jan 15 02.2
Feb 11 20.0	Jan 27 11.8	Jan 31 20.3	Feb 5 10.5
Mar 5 06.9	Feb 17 20.8	Feb 22 05.5	Feb 26 20.5
Mar 26 19.1	Mar 11 07.3	Mar 15 15.8	Mar 20 07.7
Apr 17 08.5	Apr 1 18.6	Apr 6 02.8	Apr 10 20.0
May 8 22.5	Apr 23 06.6	Apr 27 14.2	May 2 08.8
May 30 12.6	May 14 18.6	May 19 01.8	May 23 22.1
Jun 21 02.1	Jun 5 06.5	Jun 9 13.2	Jun 14 11.0
Jul 12 15.0	Jun 26 17.9	Jul 1 00.2	Jul 5 23.8
Aug 3 02.6	Jul 18 04.4	Jul 22 10.3	Jul 27 11.4
Aug 24 12.9	Aug 8 14.0	Aug 12 19.6	Aug 17 22.2
Sep 14 21.2	Aug 29 22.1	Sep 3 03.7	Sep 8 07.1
Oct 6 03.7	Sep 20 05.0	Sep 24 10.2	Sep 29 14.3
Oct 27 08.3	Oct 11 10.5	Oct 15 15.5	Oct 20 19.7
Nov 17 11.2	Nov 1 14.3	Nov 5 19.2	Nov 10 23.2
Dec 8 12.7	Nov 22 16.8	Nov 26 21.8	Dec 2 01.2
Dec 29 13.7	Dec 13 18.6	Dec 17 23.5	Dec 23 02.5

SATURN'S RINGS

Major and minor axes (in arc seconds) are for the outer edge of the outer ring. To work out the dimensions of the other rings, multiply by the following factors.

Inner edge of outer ring	0.8932
Outer edge of inner ring	0.8596
Inner edge of inner ring	0.6726
Inner edge of dusky ring	0.5477

'U' and 'B' are the geocentric longitude and the tilt of the rings respectively.

Date	Major "	Minor "	U °	B °
Jan 2	45.91	19.97	298.396	-25.786
Jan 10	45.48	19.77	297.887	-25.771
Jan 18	44.96	19.55	297.485	-25.765
Jan 26	44.40	19.30	297.202	-25.772
Feb 3	43.80	19.06	297.047	-25.792
Feb 11	43.17	18.81	297.024	-25.824
Feb 19	42.54	18.56	297.135	-25.869
Feb 27	41.91	18.32	297.377	-25.926
Mar 7	41.30	18.10	297.746	-25.992
Mar 15	40.72	17.89	298.236	-26.067
Mar 23	40.18	17.70	298.838	-26.147
Mar 31	39.67	17.53	299.543	-26.231
Apr 8	39.21	17.38	300.340	-26.315
Apr 16	38.81	17.25	301.221	-26.398
Apr 24	38.45	17.14	302.174	-26.478
May 2	38.15	17.05	303.187	-26.551
May 10	37.90	16.98	304.252	-26.617
May 18	37.71	16.93	305.357	-26.674
May 26	37.58	16.90	306.492	-26.721
Jun 3	37.50	16.88	307.645	-26.756
Jun 11	37.49	16.89	308.807	-26.780
Jun 19	37.52	16.91	309.968	-26.792
Jun 27	37.62	16.96	311.117	-26.792

Date	Major "	Minor "	U °	B °
Jul 5	37.77	17.02	312.244	-26.781
Jul 13	37.98	17.10	313.340	-26.760
Jul 21	38.24	17.20	314.393	-26.730
Jul 29	38.55	17.32	315.393	-26.692
Aug 6	38.92	17.46	316.332	-26.648
Aug 14	39.34	17.62	317.197	-26.601
Aug 22	39.81	17.80	317.980	-26.551
Aug 30	40.32	17.99	318.670	-26.502
Sep 7	40.87	18.21	319.259	-26.456
Sep 15	41.46	18.44	319.737	-26.415
Sep 23	42.07	18.69	320.096	-26.380
Oct 1	42.69	18.95	320.332	-26.354
Oct 9	43.33	19.22	320.438	-26.338
Oct 17	43.95	19.50	320.412	-26.332
Oct 25	44.56	19.77	320.256	-26.338
Nov 2	45.12	20.03	319.973	-26.355
Nov 10	45.63	20.28	319.570	-26.382
Nov 18	46.07	20.50	319.061	-26.417
Nov 26	46.42	20.68	318.463	-26.459
Dec 4	46.67	20.83	317.793	-26.505
Dec 12	46.82	20.93	317.078	-26.554
Dec 20	46.84	20.97	316.343	-26.604
Dec 28	46.74	20.97	315.615	-26.652

For more information see page 73.

TIMES OF GREATEST EASTERN ELONGATION (AEST)

RHEA Mean Synodic Period 4d 12.5h											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h
2 12.0	3 02.6	2 05.3	2 21.0	4 13.1	5 05.4	2 09.1	3 01.3	3 17.0	5 08.3	1 10.7	3 01.0
7 00.3	7 15.0	6 17.8	7 09.6	9 01.7	9 18.0	6 21.7	7 13.8	8 05.6	9 20.8	5 23.0	7 13.3
11 12.7	12 03.4	11 06.3	11 22.2	13 14.3	14 06.6	11 10.3	12 02.4	12 18.0	14 09.2	10 11.4	12 01.5
16 01.0	16 15.9	15 18.8	16 10.7	18 02.9	18 19.2	15 22.9	16 14.9	17 06.5	18 21.6	14 23.7	16 13.8
20 13.4	21 04.4	20 07.4	20 23.3	22 15.5	23 07.9	20 11.5	21 03.5	21 19.0	23 09.9	19 12.0	21 02.1
25 01.8	25 16.8	24 19.9	25 11.9	27 04.2	27 20.5	25 00.1	25 16.0	26 07.5	27 22.3	24 00.4	25 14.4
29 14.2		29 08.4	30 00.5	31 16.8		29 12.7	30 04.5	30 19.9		28 12.7	30 02.7
DIONE Mean Synodic Period 2d 17.7h											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h
3 07.8	2 10.2	1 19.2	3 15.9	1 01.4	2 22.5	3 01.8	2 05.1	1 08.1	1 10.8	3 06.9	3 09.1
6 01.5	5 03.9	4 12.9	6 09.7	3 19.2	5 16.3	5 19.6	4 22.8	4 01.8	4 04.5	6 00.6	6 02.7
8 19.1	7 21.6	7 06.6	9 03.4	6 12.9	8 10.0	8 13.3	7 16.5	6 19.5	6 22.2	8 18.3	8 20.3
11 12.8	10 15.3	10 00.4	11 21.2	9 06.7	11 03.8	11 07.1	10 10.3	9 13.2	9 15.9	11 11.9	11 14.0
14 06.5	13 09.0	12 18.1	14 14.9	12 00.5	13 21.6	14 00.9	13 04.0	12 07.0	12 09.6	14 05.6	14 07.6
17 00.1	16 02.7	15 11.8	17 08.7	14 18.2	16 15.3	16 18.6	15 21.8	15 00.7	15 03.3	16 23.2	17 01.3
19 17.8	18 20.4	18 05.5	20 02.4	17 12.0	19 09.1	19 12.3	18 15.5	17 18.4	17 20.9	19 16.9	19 18.9
22 11.5	21 14.1	20 23.3	22 20.2	20 05.7	22 02.8	22 06.1	21 09.2	20 12.1	20 14.6	22 10.5	22 12.6
25 05.2	24 07.8	23 17.0	25 13.9	22 23.5	24 20.6	24 23.8	24 02.9	23 05.8	23 08.3	25 04.1	25 06.8
27 22.8	27 01.5	26 10.7	28 07.7	25 17.2	27 14.3	27 17.6	26 20.7	25 23.5	26 02.0	27 21.8	27 23.8
30 16.5		29 04.5		28 11.0	30 08.1	30 11.3	29 14.4	28 17.2	28 19.6	30 15.4	30 17.5
		31 22.2		31 04.8					31 13.3		
TETHYS Mean Synodic Period 1d 21.3h											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h
2 14.3	1 19.1	2 02.9	1 08.1	1 13.5	2 16.3	1 00.4	2 03.1	1 08.4	1 13.4	2 15.5	2 20.1
4 11.6	3 16.4	4 00.2	3 05.4	3 10.8	4 13.7	2 21.8	4 00.5	3 05.7	3 10.7	4 12.8	4 17.4
6 08.9	5 13.7	5 21.5	5 02.8	5 08.2	6 11.0	4 19.1	5 21.8	5 03.0	5 08.0	6 10.1	6 14.7
8 06.2	7 11.1	7 18.8	7 00.1	7 05.5	8 08.3	6 16.4	7 19.1	7 00.3	7 05.3	8 07.4	8 12.0
10 03.5	9 08.4	9 16.2	8 21.5	9 02.9	10 05.7	8 13.8	9 16.5	8 21.7	9 02.6	10 04.7	10 09.3
12 00.8	11 05.7	11 13.5	10 18.8	11 00.2	12 03.0	10 11.1	11 13.8	10 19.0	10 23.9	12 02.0	12 06.6
13 22.1	13 03.0	13 10.8	12 16.1	12 21.6	14 00.4	12 08.5	13 11.1	12 16.3	12 21.2	13 23.3	14 03.9
15 19.4	15 00.3	15 08.1	14 13.5	14 18.9	15 21.7	14 05.8	15 08.5	14 13.6	14 18.5	15 20.6	16 01.1
17 16.7	16 21.6	17 05.5	16 10.8	16 16.2	17 19.1	16 03.1	17 05.8	16 10.9	16 15.8	17 17.8	17 22.4
19 14.0	18 18.9	19 02.8	18 08.1	18 13.6	19 16.4	18 00.5	19 03.1	18 08.2	18 13.1	19 15.1	19 19.7
21 11.3	20 16.3	21 00.1	20 05.5	20 10.9	21 13.7	19 21.8	21 00.4	20 05.6	20 10.4	21 12.4	21 17.0
23 08.6	22 13.6	22 21.5	22 02.8	22 08.3	23 11.1	21 19.2	22 21.8	22 02.9	22 07.7	23 09.7	23 14.3
25 05.9	24 10.9	24 18.8	24 00.2	24 05.6	25 08.4	23 16.5	24 19.1	24 00.2	24 05.0	25 07.0	25 11.6
27 03.2	26 08.2	26 16.1	25 21.5	26 03.0	27 05.8	25 13.8	26 16.4	25 21.5	26 02.3	27 04.3	27 08.9
29 00.5	28 05.5	28 13.4	27 18.8	28 00.3	29 03.1	27 11.1	28 13.7	27 18.8	27 23.6	29 01.6	29 06.1
30 21.8		30 10.8	29 16.2	29 21.6	31 19.0	29 08.5	30 11.1	29 16.1	29 20.9	30 22.9	31 03.4
						31 05.8			31 18.2		
ENCELADUS Mean Synodic Period 1d 8.9h											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h	d hh.h
2 01.8	1 05.2	1 23.9	1 03.6	1 07.4	1 20.2	2 00.1	1 03.9	1 16.5	1 20.0	2 08.3	1 02.7
3 10.6	2 14.0	3 08.7	2 12.5	2 16.3	3 05.1	3 09.0	2 12.8	3 01.4	3 04.9	3 17.2	2 11.6
4 19.5	3 22.9	4 17.6	3 21.4	4 01.2	4 14.0	4 17.9	3 21.7	4 10.3	4 13.8	5 02.0	3 20.4
6 04.4	5 07.8	6 02.5	5 06.3	5 10.1	5 22.9	6 02.8	5 06.6	5 19.2	5 22.7	6 10.9	5 05.3
7 13.3	6 16.7	7 11.4	6 15.2	6 19.1	7 07.8	7 11.7	6 15.5	7 04.1	7 07.6	7 19.8	6 14.2
8 22.1	8 01.6	8 20.3	8 00.1	8 04.0	8 16.8	8 20.6	8 00.4	8 12.9	8 16.4	9 04.7	7 23.0
10 07.0	9 10.5	10 05.2	9 09.0	9 12.9	10 01.7	10 05.5	9 09.3	9 21.8	10 01.3	10 13.6	9 07.9
11 15.9	10 19.4	11 14.1	10 17.9	10 21.8	11 10.5	11 14.4	10 18.2	11 06.7	11 10.2	11 22.4	10 16.8
13 00.8	12 04.3	12 23.0	12 02.8	12 06.7	12 19.5	12 23.3	12 03.1	12 15.6	12 19.1	13 07.3	12 01.7
14 09.7	13 13.2	14 07.9	13 11.7	13 15.6	14 04.4	14 08.2	13 12.0	14 00.5	14 04.0	14 16.2	13 10.5
15 18.5	14 22.0	15 16.8	14 20.6	15 00.5	15 13.3	15 17.1	14 20.9	15 09.4	15 12.9	16 01.1	14 19.4
17 03.4	16 06.9	17 01.7	16 05.5	16 09.4	16 22.2	17 02.0	16 05.8	16 18.3	16 21.7	17 09.9	16 04.3
18 12.3	17 15.8	18 10.6	17 14.4	17 18.3	18 07.1	18 10.9	17 14.7	18 03.2	18 06.6	18 18.8	17 13.2
19 21.2	19 00.7	19 19.5	18 23.3	19 03.2	19 16.0	19 19.8	18 23.6	19 12.1	19 15.5	20 03.7	18 22.0
21 06.1	20 09.6	21 04.4	20 08.2	20 12.1	21 00.9	21 04.7	20 08.4	20 20.9	21 00.4	21 12.6	20 06.9
22 15.0	21 18.5	22 13.3	21 17.1	21 21.0	22 09.8	22 13.6	21 17.3	22 05.8	22 09.3	22 21.4	21 15.8
23 23.8	23 03.4	23 22.2	23 02.0	23 05.9	23 18.7	23 22.5	23 02.2	23 14.7	23 18.1	24 06.3	23 00.7
25 08.7	24 12.3	25 07.1	24 10.9	24 14.8	25 03.6	25 07.4	24 11.1	24 23.6	25 03.0	25 15.2	24 09.5
26 17.6	25 21.2	26 16.0	25 19.8	25 23.7	26 12.5	26 16.3	25 20.0	26 08.5	26 11.9	27 00.1	25 18.4
28 02.5	27 06.1	28 00.9	27 04.7	27 08.6	27 21.4	28 01.2	27 04.9	27 17.4	27 20.8	28 08.9	27 03.3
29 11.4	28 15.0	29 09.8	28 13.6	28 17.5	29 06.3	29 10.1	28 13.8	29 02.3	29 05.7	29 17.8	28 12.2
30 20.3		30 18.7	29 22.5	30 02.4	30 15.2	30 19.0	29 22.7	30 11.1	30 14.5		29 21.0
				31 11.3			31 07.6		31 23.4		31 05.9

URANUS

RISE AND SET TIMES

AEST (Adelaide & Darwin ACST)

POSITION

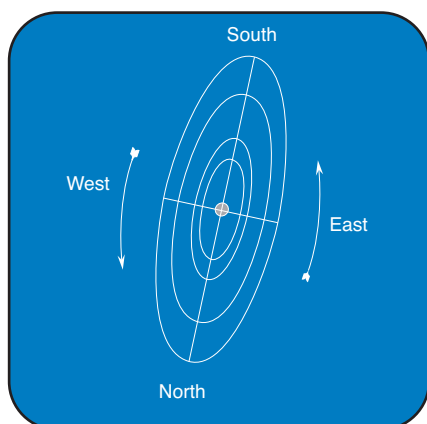
(0hrs UT Epoch 2000.0)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville		RA			DEC			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h	m	s	°	'	"	
Jan	5	08:14	21:42	07:58	21:03	08:02	21:30	09:15	21:44	07:56	21:52	08:14	21:51	07:55	21:20	08:33	21:18	21	40	52	-	14	38	03
	12	07:48	21:15	07:32	20:37	07:36	21:04	08:48	21:17	07:30	21:25	07:48	21:25	07:30	20:53	08:07	20:51	21	42	13	-	14	31	04
	19	07:22	20:49	07:06	20:11	07:10	20:37	08:22	20:51	07:04	20:59	07:22	20:58	07:04	20:27	07:41	20:25	21	43	40	-	14	23	43
	26	06:57	20:22	06:40	19:44	06:44	20:11	07:57	20:25	06:39	20:32	06:57	20:32	06:38	20:00	07:15	19:59	21	45	09	-	14	16	02
Feb	2	06:31	19:56	06:14	19:18	06:19	19:45	07:31	19:59	06:13	20:05	06:31	20:05	06:12	19:34	06:49	19:33	21	46	41	-	14	08	09
	9	06:06	19:30	05:49	18:52	05:53	19:18	07:05	19:33	05:48	19:39	06:06	19:39	05:47	19:08	06:24	19:07	21	48	15	-	14	00	06
	16	05:40	19:03	05:23	18:25	05:28	18:52	06:39	19:07	05:22	19:12	05:40	19:12	05:21	18:41	05:58	18:40	21	49	49	-	13	51	59
	23	05:15	18:37	04:57	17:59	05:02	18:25	06:13	18:41	04:57	18:46	05:15	18:46	04:56	18:15	05:32	18:14	21	51	23	-	13	43	53
Mar	2	04:49	18:11	04:32	17:33	04:37	17:59	05:47	18:14	04:32	18:19	04:49	18:20	04:30	17:49	05:06	17:48	21	52	56	-	13	35	54
	9	04:23	17:44	04:06	17:07	04:11	17:33	05:21	17:48	04:06	17:53	04:23	17:53	04:05	17:22	04:40	17:22	21	54	26	-	13	28	06
	16	03:58	17:18	03:40	16:40	03:45	17:06	04:55	17:22	03:40	17:26	03:58	17:27	03:39	16:56	04:15	16:56	21	55	53	-	13	20	34
	23	03:32	16:51	03:14	16:14	03:20	16:40	04:29	16:56	03:15	17:00	03:32	17:00	03:13	16:29	03:49	16:29	21	57	16	-	13	13	23
30	03:06	16:25	02:48	15:47	02:54	16:13	04:03	16:29	02:49	16:33	03:06	16:33	02:47	16:03	03:23	16:03	21	58	34	-	13	06	38	
Apr	6	02:40	15:58	02:22	15:21	02:28	15:46	03:37	16:03	02:23	16:06	02:40	16:07	02:21	15:36	02:56	15:36	21	59	47	-	13	00	23
	13	02:14	15:31	01:56	14:54	02:02	15:20	03:11	15:37	01:57	15:39	02:14	15:40	01:55	15:09	02:30	15:10	22	00	53	-	12	54	41
	20	01:48	15:04	01:30	14:27	01:35	14:53	02:44	15:10	01:31	15:13	01:48	15:13	01:29	14:43	02:04	14:43	22	01	52	-	12	49	39
	27	01:21	14:38	01:03	14:01	01:09	14:26	02:18	14:43	01:05	14:46	01:22	14:46	01:02	14:16	01:37	14:16	22	02	43	-	12	45	17
May	4	00:54	14:11	00:37	13:34	00:42	13:59	01:51	14:16	00:38	14:19	00:55	14:19	00:36	13:49	01:10	13:49	22	03	26	-	12	41	40
	11	00:28	13:43	00:10	13:07	00:15	13:32	01:24	13:49	00:11	13:51	00:28	13:52	00:09	13:22	00:44	13:22	22	04	01	-	12	38	49
	18	23:57	13:16	23:39	12:39	23:45	13:05	00:57	13:22	23:40	13:24	23:57	13:25	23:38	12:54	00:17	12:55	22	04	26	-	12	36	47
	25	23:30	12:49	23:12	12:12	23:17	12:37	00:30	12:55	23:13	12:57	23:30	12:58	23:11	12:27	23:45	12:28	22	04	43	-	12	35	34
Jun	1	23:02	12:22	22:44	11:45	22:50	12:10	23:58	12:27	22:46	12:29	23:03	12:30	22:43	12:00	23:18	12:01	22	04	50	-	12	35	12
	8	22:35	11:54	22:17	11:17	22:22	11:42	23:31	12:00	22:18	12:02	22:35	12:03	22:16	11:32	22:50	11:33	22	04	49	-	12	35	39
	15	22:07	11:26	21:49	10:50	21:55	11:15	23:03	11:32	21:50	11:34	22:07	11:35	21:48	11:05	22:23	11:05	22	04	38	-	12	36	55
	22	21:39	10:59	21:21	10:22	21:27	10:47	22:35	11:04	21:22	11:07	21:39	11:07	21:20	10:37	21:55	10:38	22	04	18	-	12	38	59
29	21:11	10:31	20:53	09:54	20:58	10:19	22:07	10:37	20:54	10:39	21:11	10:40	20:52	10:09	21:27	10:10	22	03	50	-	12	41	46	
Jul	6	20:42	10:03	20:25	09:26	20:30	09:51	21:39	10:08	20:26	10:11	20:43	10:12	20:24	09:41	20:59	09:42	22	03	14	-	12	45	15
	13	20:14	09:35	19:56	08:58	20:02	09:23	21:11	09:40	19:57	09:43	20:14	09:44	19:55	09:13	20:30	09:13	22	02	31	-	12	49	20
	20	19:45	09:07	19:28	08:30	19:33	08:55	20:42	09:12	19:29	09:15	19:46	09:15	19:27	08:45	20:02	08:45	22	01	42	-	12	53	58
	27	19:17	08:39	18:59	08:01	19:04	08:27	20:14	08:44	19:00	08:47	19:17	08:47	18:58	08:17	19:33	08:17	22	00	47	-	12	59	01
Aug	3	18:48	08:10	18:30	07:33	18:36	07:59	19:45	08:15	18:31	08:19	18:48	08:19	18:29	07:48	19:05	07:49	21	59	48	-	13	04	25
	10	18:19	07:42	18:02	07:05	18:07	07:31	19:17	07:47	18:02	07:50	18:19	07:51	18:00	07:20	18:36	07:20	21	58	46	-	13	10	03
	17	17:50	07:14	17:33	06:36	17:38	07:02	18:48	07:18	17:33	07:22	17:51	07:23	17:32	06:52	18:07	06:52	21	57	42	-	13	15	48
	24	17:21	06:45	17:04	06:08	17:09	06:34	18:19	06:50	17:04	06:54	17:22	06:54	17:03	06:24	17:38	06:23	21	56	38	-	13	21	32
31	16:53	06:17	16:35	05:40	16:40	06:06	17:51	06:21	16:35	06:26	16:53	06:26	16:34	05:55	17:10	05:55	21	55	34	-	13	27	10	
Sep	7	16:24	05:49	16:07	05:11	16:11	05:37	17:22	05:53	16:06	05:58	16:24	05:58	16:05	05:27	16:41	05:26	21	54	31	-	13	32	34
	14	15:55	05:21	15:38	04:43	15:43	05:09	16:53	05:24	15:38	05:30	15:55	05:30	15:36	04:59	16:12	04:58	21	53	33	-	13	37	38
	21	15:26	04:52	15:09	04:15	15:14	04:41	16:25	04:56	15:09	05:01	15:26	05:01	15:08	04:30	15:44	04:30	21	52	38	-	13	42	15
	28	14:58	04:24	14:41	03:47	14:45	04:13	15:57	04:28	14:40	04:33	14:58	04:33	14:39	04:02	15:15	04:02	21	51	49	-	13	46	20
Oct	5	14:29	03:56	14:12	03:18	14:17	03:45	15:28	04:00	14:12	04:05	14:29	04:05	14:11	03:34	14:47	03:33	21	51	07	-	13	49	48
	12	14:01	03:28	13:44	02:50	13:49	03:17	15:00	03:32	13:44	03:37	14:01	03:37	13:42	03:06	14:19	03:05	21	50	33	-	13	52	36
	19	13:33	03:00	13:16	02:23	13:21	02:49	14:32	03:04	13:15	03:10	13:33	03:10	13:14	02:38	13:51	02:37	21	50	06	-	13	54	38
	26	13:05	02:33	12:48	01:55	12:53	02:21	14:04	02:36	12:48	02:42	13:05	02:42	12:47	02:11	13:23	02:10	21	49	49	-	13	55	54
Nov	2	12:38	02:05	12:21	01:27	12:25	01:54	13:37	02:08	12:20	02:14	12:38	02:14	12:19	01:43	12:55	01:42	21	49	41	-	13	56	20
	9	12:10	01:37	11:53	01:00	11:58	01:26	13:09	01:41	11:52	01:47	12:10	01:47	11:51	01:16	12:28	01:14	21	49	42	-	13	55	57
	16	11:43	01:10	11:26	00:32	11:30	00:59	12:42	01:13	11:25	01:19	11:43	01:19	11:24	00:48	12:01	00:47	21	49	53	-	13	54	42
	23	11:16	00:43	10:59	00:05	11:03	00:31	12:15	00:46	10:58	00:52	11:16	00:52	10:57	00:21	11:33	00:20	21	50					

SATELLITES OF URANUS — GREATEST NORTHERN ELONGATION (AEST)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ARIEL											
1 05.3	2 23.6	2 17.0	1 22.8	2 04.5	1 10.4	1 16.1	3 10.5	2 16.4	2 22.3	2 04.3	2 10.2
3 17.8	5 12.1	5 05.4	4 11.2	4 17.0	3 22.8	4 04.6	5 23.0	5 04.9	5 10.8	4 16.8	4 22.7
6 06.2	8 00.6	7 17.9	6 23.8	7 05.5	6 11.3	6 17.1	8 11.5	7 17.4	7 23.3	7 05.3	7 11.2
8 18.7	10 13.1	10 06.4	9 12.2	9 18.0	8 23.8	9 05.6	11 00.0	10 05.9	10 11.8	9 17.7	9 23.7
11 07.2	13 01.6	12 18.9	12 00.7	12 06.5	11 12.3	11 18.1	13 12.4	12 18.3	13 00.3	12 06.3	12 12.1
13 19.7	15 14.1	15 07.4	14 13.2	14 18.9	14 00.8	14 06.6	16 01.0	15 06.9	15 12.8	14 18.7	15 00.7
16 08.2	18 02.6	17 19.9	17 01.7	17 07.4	16 13.3	16 19.1	18 13.5	17 19.3	18 01.3	17 07.3	17 13.2
18 20.7	20 15.0	20 08.4	19 14.2	19 19.9	19 01.7	19 07.6	21 01.9	20 07.9	20 13.8	19 19.8	20 01.6
21 09.2	23 03.5	22 20.8	22 02.6	22 08.4	21 14.2	21 20.1	23 14.4	22 20.3	23 02.3	22 08.3	22 14.2
23 21.7	25 16.0	25 09.3	24 15.1	24 20.9	24 02.7	24 08.6	26 02.9	25 08.9	25 14.8	24 20.8	25 02.6
26 10.2	28 04.5	27 21.8	27 03.6	27 09.4	26 15.2	26 21.1	28 15.4	27 21.3	28 03.3	27 09.2	27 15.1
28 22.6		30 10.3	29 16.1	29 21.8	29 03.7	29 09.5	31 03.9	30 09.9	30 15.8	29 21.7	30 03.6
31 11.2						31 22.0					
UMBRIEL											
2 19.3	4 22.9	1 19.7	3 23.4	2 23.3	5 02.9	4 03.3	2 03.5	4 07.0	3 07.4	1 07.8	4 11.5
6 22.7	9 02.4	5 23.2	8 02.8	7 02.7	9 06.4	8 06.8	6 06.9	8 10.5	7 10.9	5 11.3	8 15.0
11 02.2	13 05.9	10 02.7	12 06.2	11 06.2	13 09.9	12 10.2	10 10.3	12 14.1	11 14.3	9 14.7	12 18.5
15 05.6	17 09.4	14 06.2	16 09.6	15 09.6	17 13.2	16 13.6	14 13.9	16 17.5	15 17.7	13 18.2	16 21.9
19 09.1	25 16.2	18 09.6	20 13.1	19 13.1	21 16.7	20 17.1	18 17.3	20 20.9	19 21.3	17 21.7	21 01.3
23 12.6		22 13.0	24 16.5	23 16.5	25 20.2	24 20.6	22 20.8	25 00.4	24 00.8	22 01.2	25 04.8
27 16.0		26 16.5	28 19.9	27 19.9	29 23.8	29 00.0	27 00.2	29 03.9	28 04.3	26 04.6	29 08.2
31 19.4		30 19.9		31 23.4			31 03.6			30 08.1	
TITANIA											
	1 17.7	8 13.4	3 16.1	8 11.7	3 14.4	8 10.1	3 13.0	7 09.1	3 12.0	7 07.8	3 10.5
6 15.0	10 10.7	17 06.3	12 09.0	17 04.6	12 07.3	17 03.0	12 06.0	16 02.0	12 05.0	16 00.7	12 03.4
15 08.0	19 03.5	25 23.2	21 01.9	25 21.5	21 00.2	25 20.0	20 23.0	24 19.1	20 21.9	24 17.6	20 20.4
24 00.8	27 20.4		29 18.8		29 17.1		29 16.1		29 14.9		29 13.4
OBERON											
2 01.1	11 10.2	10 08.2	6 06.1	3 04.2	12 13.6	9 12.0	5 10.3	1 08.5	11 18.1	7 16.5	4 14.9
15 12.2	24 21.2	23 19.1	19 17.1	16 15.3	26 00.8	22 23.2	18 21.4	14 19.7	25 05.3	21 03.8	18 02.0
28 23.2				30 02.4				28 06.9			31 13.0

SATELLITES OF URANUS

Apparent orbit of Satellites I-IV at date of opposition, August 20th.

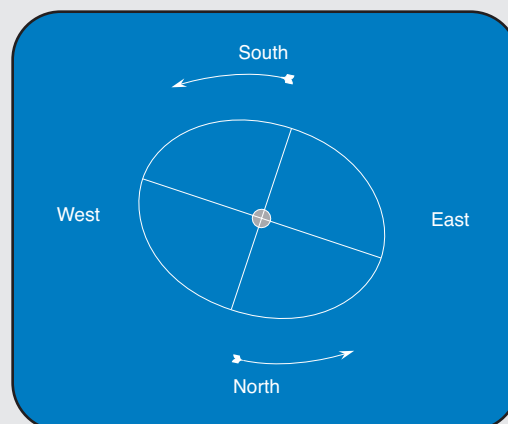


Name	Sidereal Period
	d h
I Ariel	2 12.489
II Umbriel	4 03.460
III Titania	8 16.941
IV Oberon	13 11.118

See introduction to Part II (p. 74) for more information.

SATELLITE OF NEPTUNE

Apparent orbit of Triton at date of opposition, August 2nd



Name	Sidereal Period
	d h
I Triton	5 21.044

See introduction to Part II (p. 74) for more information.

SATELLITE OF NEPTUNE — GREATEST EASTERN ELONGATION (AEST)											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TRITON											
1 12.6	5 18.0	1 05.7	5 11.3	4 20.2	3 05.5	2 14.9	1 00.6	5 07.4	4 17.0	3 02.3	2 11.4
7 09.5	11 14.9	7 02.6	11 08.3	10 17.3	9 02.5	8 12.1	6 21.7	11 04.6	10 14.1	8 23.3	8 08.3
13 06.4	17 11.9	12 23.5	17 05.3	16 14.3	14 23.6	14 09.2	12 18.9	17 01.7	16 11.2	14 20.4	14 05.3
19 03.3	23 08.8	18 20.5	23 02.2	22 11.3	20 20.7	20 06.3	18 16.0	22 22.8	22 08.2	20 17.4	20 02.2
25 00.2		24 17.4	28 23.2	28 08.4	26 17.8	26 03.5	24 13.2	28 19.9	28 05.3	26 14.4	25 23.2
30 21.1		30 14.3					30 10.3				31 20.1

NEPTUNE

RISE AND SET TIMES

AEST (Adelaide & Darwin ACST)

POSITION

(0hrs UT Epoch 2000.0)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville		RA			DEC			
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h	m	s	°	'	"	
Jan	5	07:02	20:52	06:48	20:11	06:49	20:41	08:10	20:46	06:39	21:06	07:00	21:03	06:43	20:30	07:26	20:22	20	39	47	-	18	16	39
	12	06:35	20:26	06:22	19:44	06:23	20:14	07:44	20:20	06:13	20:39	06:34	20:36	06:17	20:03	07:00	19:56	20	40	49	-	18	12	51
	19	06:09	19:59	05:56	19:18	05:57	19:48	07:17	19:53	05:47	20:13	06:08	20:10	05:51	19:36	06:34	19:29	20	41	53	-	18	08	54
	26	05:43	19:32	05:29	18:51	05:30	19:21	06:51	19:27	05:21	19:46	05:41	19:43	05:25	19:10	06:07	19:03	20	42	57	-	18	04	52
Feb	2	05:17	19:06	05:03	18:24	05:04	18:54	06:24	19:00	04:55	19:19	05:15	19:16	04:58	18:43	05:41	18:36	20	44	02	-	18	00	48
	9	04:50	18:39	04:37	17:58	04:38	18:28	05:58	18:33	04:28	18:52	04:49	18:50	04:32	18:16	05:15	18:10	20	45	07	-	17	56	43
	16	04:24	18:12	04:10	17:31	04:12	18:01	05:32	18:07	04:02	18:26	04:23	18:23	04:06	17:50	04:48	17:43	20	46	10	-	17	52	42
	23	03:58	17:45	03:44	17:04	03:45	17:34	05:05	17:40	03:36	17:59	03:56	17:56	03:40	17:23	04:22	17:16	20	47	11	-	17	48	47
Mar	2	03:32	17:19	03:18	16:38	03:19	17:07	04:39	17:14	03:10	17:32	03:30	17:29	03:13	16:56	03:55	16:50	20	48	09	-	17	45	01
	9	03:05	16:52	02:51	16:11	02:53	16:41	04:12	16:47	02:43	17:05	03:04	17:02	02:47	16:30	03:29	16:23	20	49	04	-	17	41	27
	16	02:39	16:25	02:25	15:44	02:26	16:14	03:46	16:20	02:17	16:38	02:37	16:36	02:20	16:03	03:02	15:56	20	49	55	-	17	38	07
	23	02:12	15:58	01:58	15:17	02:00	15:47	03:19	15:54	01:50	16:11	02:11	16:09	01:54	15:36	02:36	15:29	20	50	42	-	17	35	04
	30	01:45	15:31	01:31	14:50	01:33	15:20	02:52	15:27	01:24	15:44	01:44	15:42	01:27	15:09	02:09	15:03	20	51	24	-	17	32	20
Apr	6	01:19	15:04	01:05	14:23	01:06	14:53	02:25	15:00	00:57	15:17	01:17	15:15	01:00	14:42	01:42	14:36	20	52	01	-	17	29	56
	13	00:52	14:37	00:38	13:56	00:39	14:26	01:58	14:33	00:30	14:50	00:50	14:47	00:33	14:15	01:15	14:09	20	52	31	-	17	27	56
	20	00:25	14:10	00:11	13:29	00:12	13:59	01:31	14:06	23:59	14:23	00:23	14:20	00:06	13:47	00:48	13:41	20	52	56	-	17	26	20
	27	23:54	13:43	23:40	13:02	23:41	13:31	01:04	13:38	23:32	13:56	23:52	13:53	23:35	13:20	00:21	13:14	20	53	14	-	17	25	09
May	4	23:26	13:15	23:12	12:35	23:14	13:04	00:37	13:11	23:05	13:28	23:25	13:26	23:08	12:53	23:50	12:47	20	53	26	-	17	24	24
	11	22:59	12:48	22:45	12:07	22:46	12:36	00:09	12:44	22:37	13:01	22:58	12:58	22:41	12:25	23:22	12:19	20	53	31	-	17	24	06
	18	22:31	12:20	22:17	11:40	22:19	12:09	23:38	12:16	22:10	12:33	22:30	12:31	22:13	11:58	22:55	11:52	20	53	30	-	17	24	14
	25	22:04	11:53	21:50	11:12	21:51	11:41	23:10	11:48	21:42	12:06	22:02	12:03	21:45	11:30	22:27	11:24	20	53	23	-	17	24	48
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PLUTO

RISE AND SET TIMES

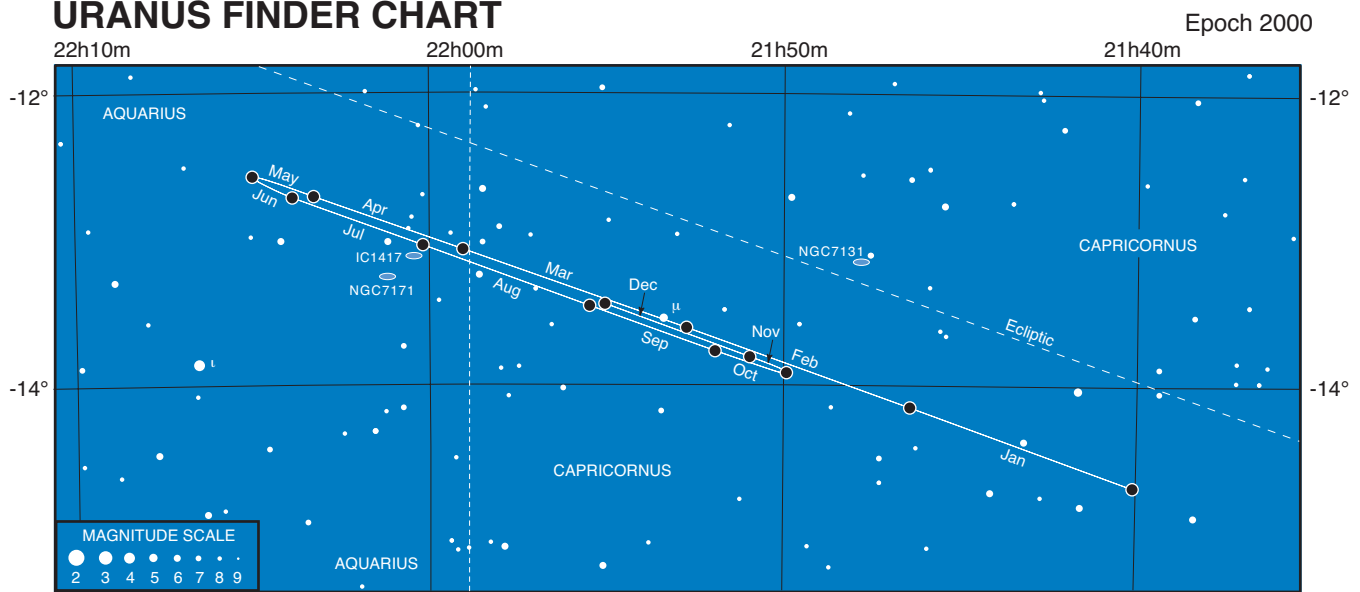
AEST (Adelaide & Darwin ACST)

POSITION

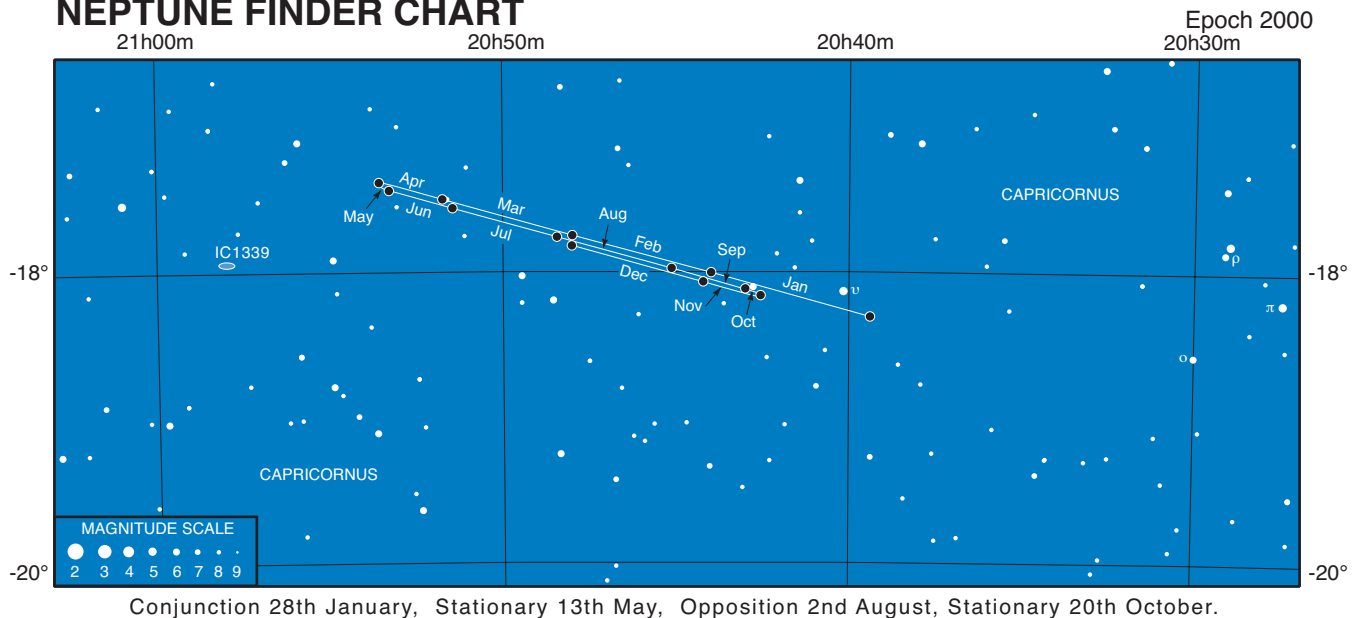
(0hrs UT Epoch 2000.0)

		Adelaide		Brisbane		Canberra		Darwin		Hobart		Melbourne		Sydney		Townsville		RA	DEC
		Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	h m s	° ' "
Jan	5	03:43	17:01	03:25	16:24	03:30	16:49	04:40	17:06	03:26	17:09	03:43	17:10	03:24	16:39	03:59	16:39	17 03 59	- 13 00 10
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	19	02:49	16:08	02:32	15:30	02:37	15:56	03:47	16:13	02:33	16:16	02:50	16:16	02:31	15:46	03:06	15:46	17 05 51	- 13 01 27
	26	02:23	15:41	02:05	15:04	02:10	15:29	03:20	15:46	02:06	15:49	02:23	15:50	02:04	15:19	02:39	15:19	17 06 40	- 13 01 36
Feb	2	01:56	15:14	01:38	14:37	01:44	15:03	02:53	15:19	01:39	15:22	01:56	15:23	01:37	14:52	02:12	14:53	17 07 25	- 13 01 27
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Apr	6	21:47	11:08	21:29	10:31	21:35	10:57	22:44	11:13	21:31	11:16	21:48	11:17	21:28	10:46	22:03	10:47	17 09 36	- 12 50 08
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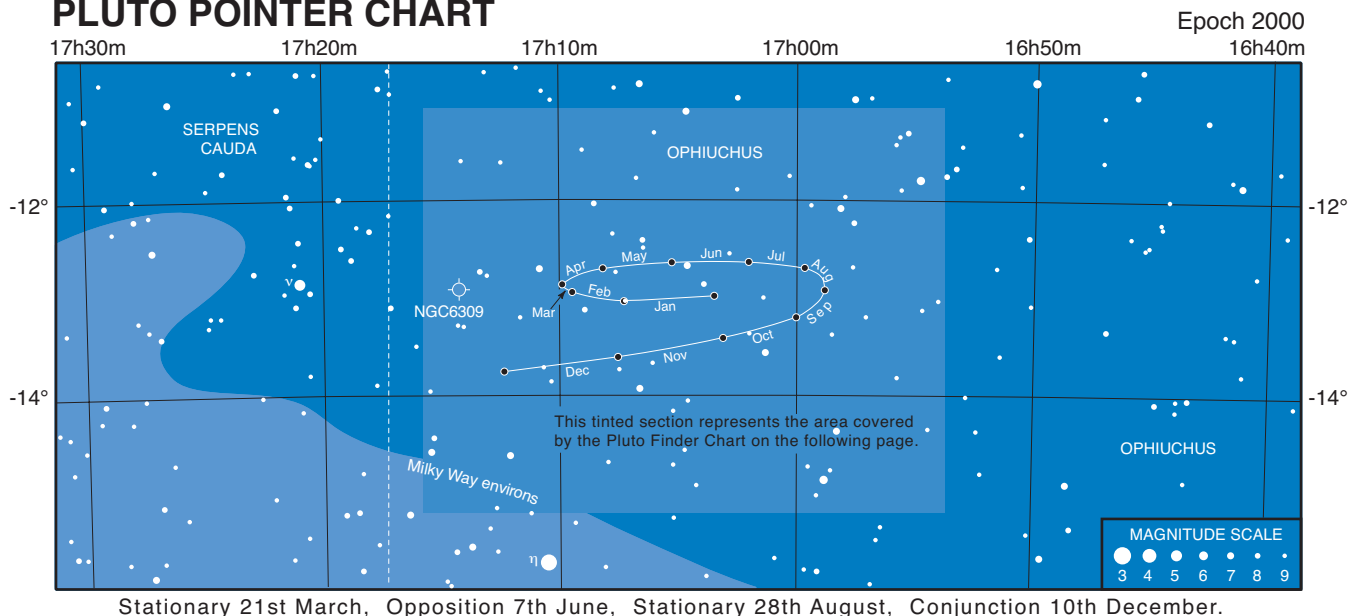
URANUS FINDER CHART



NEPTUNE FINDER CHART



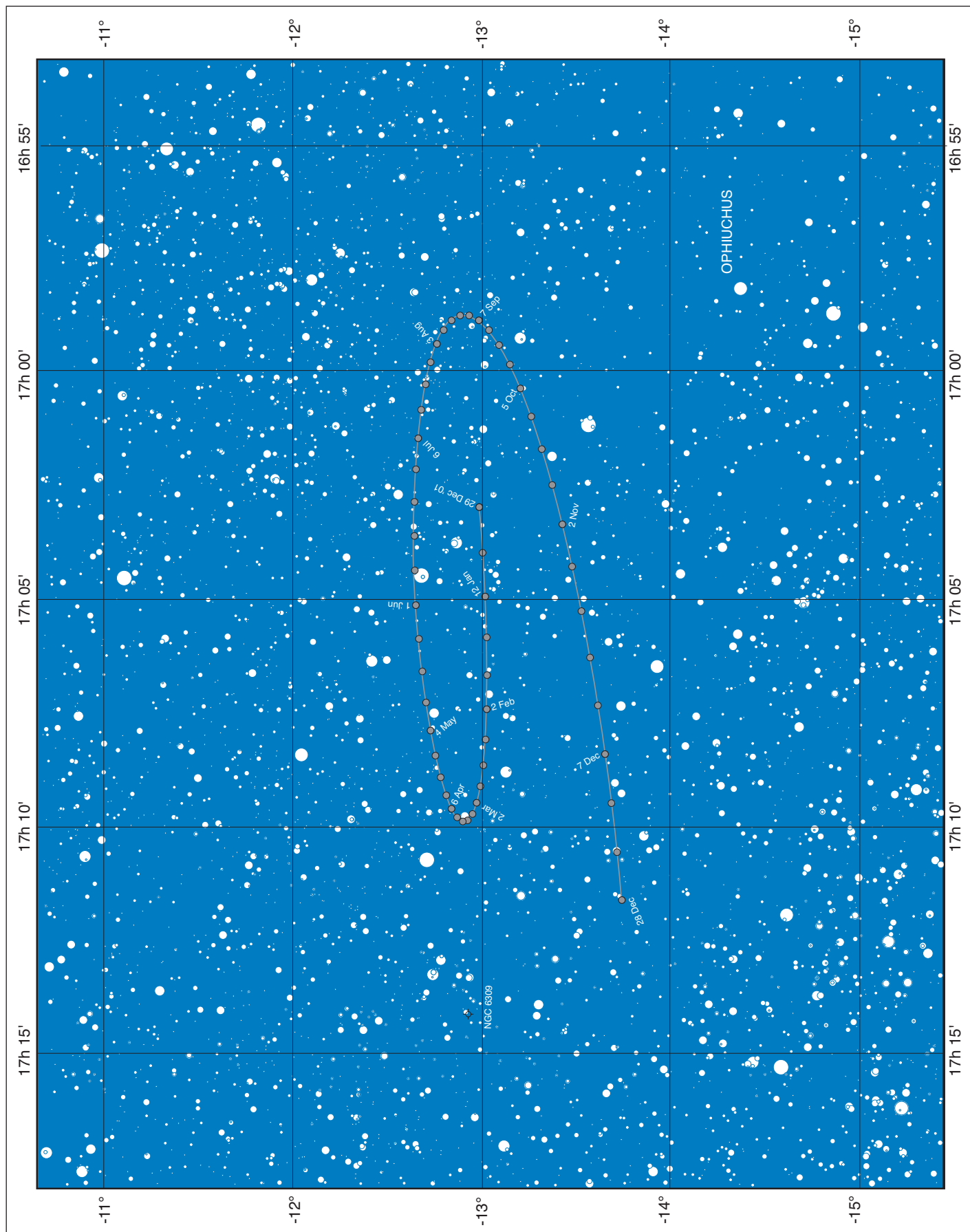
PLUTO POINTER CHART



See introduction to Part II (p. 74) for more information.

PLUTO FINDER CHART 2002

Epoch 2000.0



Pluto is shown at weekly intervals. See introduction to Part II (p. 74) for more information.

MINOR PLANET POSITIONS (0hr UT, Epoch 2000.0)

		1 CERES			2 PALLAS			3 JUNO			4 VESTA			5 ASTRAEA		
		R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.
		hr	min		hr	min		hr	min		hr	min		hr	min	
Jan	5	21 02.9	-24 16	9.2	19 01.1	+02 38	10.4	09 49.7	+00 00	8.8	03 48.2	+14 46	7.2	22 11.4	-12 59	12.8
	12	21 14.0	-23 30	9.2	19 10.9	+02 45	10.4	09 46.9	+00 23	8.7	03 46.4	+15 07	7.4	22 20.5	-12 12	12.8
	19	21 25.1	-22 42	9.2	19 20.5	+02 57	10.4	09 42.9	+01 00	8.6	03 46.2	+15 33	7.5	22 29.7	-11 22	12.8
	26	21 36.2	-21 52	9.1	19 30.1	+03 13	10.5	09 37.8	+01 49	8.5	03 47.4	+16 01	7.6	22 39.2	-10 30	12.8
Feb	2	21 47.3	-21 01	9.1	19 39.5	+03 33	10.5	09 32.1	+02 48	8.4	03 49.9	+16 33	7.7	22 48.7	-09 36	12.7
	9	21 58.3	-20 08	9.0	19 48.7	+03 58	10.5	09 26.1	+03 56	8.3	03 53.6	+17 06	7.8	22 58.4	-08 41	12.7
	16	22 09.3	-19 14	9.0	19 57.6	+04 26	10.5	09 20.2	+05 08	8.4	03 58.5	+17 41	7.9	23 08.3	-07 43	12.6
	23	22 20.1	-18 19	9.0	20 06.4	+04 57	10.5	09 14.8	+06 22	8.6	04 04.4	+18 17	8.0	23 18.2	-06 45	12.6
Mar	2	22 30.9	-17 24	9.1	20 14.9	+05 32	10.6	09 10.3	+07 33	8.7	04 11.2	+18 53	8.1	23 28.1	-05 46	12.5
	9	22 41.5	-16 28	9.1	20 23.0	+06 09	10.6	09 07.0	+08 41	8.9	04 18.9	+19 29	8.2	23 38.1	-04 45	12.4
	16	22 52.0	-15 32	9.2	20 30.9	+06 49	10.6	09 04.9	+09 41	9.1	04 27.3	+20 04	8.2	23 48.2	-03 45	12.3
	23	23 02.4	-14 37	9.2	20 38.3	+07 31	10.6	09 04.1	+10 34	9.3	04 36.4	+20 37	8.3	23 58.3	-02 44	12.3
	30	23 12.6	-13 42	9.3	20 45.4	+08 15	10.6	09 04.6	+11 18	9.4	04 46.1	+21 09	8.3	00 08.4	-01 43	12.4
Apr	6	23 22.6	-12 47	9.3	20 52.0	+09 00	10.5	09 06.4	+11 54	9.6	04 56.4	+21 38	8.4	00 18.5	-00 43	12.5
	13	23 32.5	-11 54	9.3	20 58.2	+09 46	10.5	09 09.4	+12 21	9.7	05 07.1	+22 05	8.4	00 28.6	+00 17	12.5
	20	23 42.2	-11 03	9.3	21 03.8	+10 33	10.5	09 13.4	+12 40	9.9	05 18.3	+22 29	8.4	00 38.7	+01 16	12.6
	27	23 51.7	-10 13	9.3	21 08.8	+11 20	10.5	09 18.4	+12 51	10.0	05 29.9	+22 50	8.4	00 48.8	+02 15	12.6
May	4	00 00.9	-09 25	9.3	21 13.2	+12 06	10.4	09 24.2	+12 56	10.2	05 41.8	+23 07	8.4	00 58.8	+03 11	12.6
	11	00 09.9	-08 40	9.3	21 17.0	+12 51	10.4	09 30.7	+12 53	10.3	05 54.1	+23 20	8.4	01 08.8	+04 07	12.6
	18	00 18.7	-07 58	9.3	21 20.0	+13 33	10.3	09 37.7	+12 45	10.4	06 06.6	+23 30	8.4	01 18.8	+05 00	12.6
	25	00 27.1	-07 19	9.3	21 22.3	+14 13	10.3	09 45.4	+12 31	10.5	06 19.3	+23 35	8.4	01 28.6	+05 52	12.6
Jun	1	00 35.2	-06 43	9.2	21 23.7	+14 50	10.2	09 53.4	+12 11	10.6	06 32.2	+23 36	8.4	01 38.4	+06 41	12.6
	8	00 43.0	-06 11	9.2	21 24.3	+15 22	10.1	10 01.8	+11 47	10.6	06 45.2	+23 33	8.4	01 48.1	+07 27	12.6
	15	00 50.3	-05 43	9.2	21 23.9	+15 47	10.0	10 10.5	+11 19	10.7	06 58.4	+23 25	8.3	01 57.6	+08 11	12.6
	22	00 57.1	-05 20	9.1	21 22.7	+16 06	9.9	10 19.5	+10 47	10.8	07 11.6	+23 13	8.3	02 06.9	+08 52	12.5
	29	01 03.5	-05 02	9.0	21 20.5	+16 17	9.8	10 28.6	+10 11	10.8	07 24.9	+22 57	8.3	02 16.1	+09 30	12.5
Jul	6	01 09.2	-04 48	9.0	21 17.5	+16 18	9.8	10 38.0	+09 33	10.9	07 38.2	+22 37	8.2	02 25.0	+10 04	12.4
	13	01 14.3	-04 41	8.9	21 13.7	+16 08	9.7	10 47.5	+08 51	10.9	07 51.6	+22 13	8.1	02 33.6	+10 35	12.4
	20	01 18.7	-04 39	8.8	21 09.1	+15 47	9.6	10 57.1	+08 07	11.0	08 04.9	+21 44	8.0	02 41.9	+11 01	12.3
	27	01 22.2	-04 43	8.7	21 04.1	+15 14	9.5	11 06.7	+07 21	11.0	08 18.1	+21 12	8.0	02 49.7	+11 24	12.2
Aug	3	01 24.9	-04 54	8.6	20 58.8	+14 29	9.4	11 16.5	+06 34	11.0	08 31.4	+20 36	8.1	02 57.1	+11 42	12.1
	10	01 26.6	-05 11	8.5	20 53.3	+13 33	9.4	11 26.3	+05 45	11.0	08 44.5	+19 57	8.2	03 03.9	+11 55	12.0
	17	01 27.2	-05 33	8.4	20 48.0	+12 26	9.4	11 36.2	+04 54	11.0	08 57.6	+19 15	8.2	03 10.1	+12 04	11.9
	24	01 26.8	-06 01	8.3	20 43.0	+11 11	9.4	11 46.0	+04 03	11.0	09 10.5	+18 29	8.2	03 15.5	+12 08	11.8
	31	01 25.2	-06 34	8.1	20 38.7	+09 49	9.4	11 55.9	+03 11	11.0	09 23.3	+17 42	8.3	03 20.0	+12 07	11.7
Sep	7	01 22.5	-07 10	8.0	20 35.0	+08 24	9.5	12 05.9	+02 19	11.0	09 36.1	+16 51	8.3	03 23.5	+12 01	11.6
	14	01 18.8	-07 47	7.9	20 32.3	+06 57	9.6	12 15.8	+01 27	11.0	09 48.6	+15 59	8.3	03 26.0	+11 50	11.4
	21	01 14.1	-08 25	7.7	20 30.5	+05 31	9.7	12 25.7	+00 35	10.9	10 01.1	+15 05	8.3	03 27.3	+11 33	11.3
	28	01 08.8	-09 01	7.6	20 29.7	+04 08	9.8	12 35.6	-00 16	10.9	10 13.3	+14 10	8.3	03 27.2	+11 12	11.1
Oct	5	01 02.9	-09 32	7.6	20 29.9	+02 48	9.9	12 45.4	-01 07	10.9	10 25.4	+13 15	8.3	03 25.9	+10 46	10.9
	12	00 57.0	-09 57	7.6	20 31.1	+01 34	10.0	12 55.3	-01 56	11.0	10 37.4	+12 18	8.3	03 23.2	+10 15	10.8
	19	00 51.1	-10 15	7.7	20 33.3	+00 26	10.0	13 05.0	-02 44	11.0	10 49.1	+11 22	8.2	03 19.2	+09 42	10.6
	26	00 45.7	-10 23	7.9	20 36.3	-00 35	10.1	13 14.7	-03 30	11.1	11 00.6	+10 26	8.2	03 14.0	+09 07	10.4
Nov	2	00 41.0	-10 22	8.0	20 40.2	-01 29	10.2	13 24.4	-04 15	11.2	11 12.0	+09 31	8.2	03 08.0	+08 32	10.2
	9	00 37.2	-10 11	8.1	20 44.8	-02 17	10.3	13 33.9	-04 57	11.2	11 23.0	+08 38	8.1	03 01.5	+07 58	10.1
	16	00 34.5	-09 52	8.2	20 50.1	-02 57	10.3	13 43.3	-05 36	11.2	11 33.8	+07 47	8.1	02 54.9	+07 29	10.2
	23	00 32.9	-09 24	8.4	20 56.1	-03 30	10.3	13 52.5	-06 13	11.3	11 44.3	+06 58	8.0	02 48.5	+07 05	10.3
	30	00 32.3	-08 49	8.5	21 02.6	-03 57	10.4	14 01.6	-06 47	11.3	11 54.4	+06 12	8.0	02 42.8	+06 49	10.4
Dec	7	00 32.9	-08 07	8.6	21 09.5	-04 18	10.4	14 10.5	-07 17	11.3	12 04.2	+05 30	7.9	02 38.1	+06 41	10.6
	14	00 34.6	-07 20	8.7	21 16.9	-04 32	10.4	14 19.1	-07 44	11.3	12 13.5	+04 53	7.8	02 34.7	+06 42	10.7
	21	00 37.3	-06 28	8.8	21 24.7	-04 41	10.4	14 27.5	-08 07	11.3	12 22.3	+04 21	7.7	02 32.6	+06 52	10.8
	28	00 40.8	-05 31	8.8	21 32.8	-04 45	10.4	14 35.5	-08 26	11.3	12 30.5	+03 54	7.6	02 32.0	+07 10	11.0

		6 HEBE			7 IRIS			8 FLORA			9 METIS			15 EUNOMIA		
Jan	5	16 43.3	-10 46	11.3	18 25.5	-22 24	10.8	11 06.0	+10 24	10.1	07 50.2	+27 51	8.7	19 04.9	-23 54	10.3
	12	16 54.6	-10 59	11.2	18 38.4	-22 08	10.8	11 06.6	+10 49	10.0	07 42.5	+28 30	8.6	19 17.9	-23 19	10.4
	19	17 05.7	-11 08	11.2	18 51.2	-21 48	10.9	11 05.7	+11 26	9.9	07 34.7	+29 02	8.7	19 30.8	-22 39	10.5
	26	17 16.7	-11 13	11.2	19 04.0	-21 23	10.9	11 03.2	+12 11	9.7	07 27.4	+29 27	8.9	19 43.6	-21 56	10.5
Feb	2	17 27.5	-11 13	11.2	19 16.7	-20 55	10.9	10 59.1	+13 05	9.6	07 21.2	+29 42	9.1	19 56.3	-21 08	10.6
	9	17 38.0	-11 09	11.1	19 29.3	-20 22	10.9	10 53.7	+14 04	9.4	07 16.5	+29 50	9.3	20 08.9	-20 17	10.6
	16	17 48.2	-11 01	11.1	19 41.7	-19 46	10.9	10 47.3	+15 05	9.3	07 13.6	+29 50	9.5	20 21.3	-19 22	10.6
	23	17 58.1	-10 49	11.0	19 54.0	-19 06	10.9	10 40.2	+16 05	9.2	07 12.5	+29 44	9.7	20 33.6	-18 24	10.6
Mar	2	18 07.6	-10 33	11.0	20 06.1	-18 23	10.9	10 33.0	+16 59	9.3	07 13.3	+29 33	9.9	20 45.7	-17 22	10.6
	9	18 16.7	-10 14	10.9	20 17.9	-17 36	10.9	10 26.1	+17 45	9.5	07 15.8	+29 18	10.0	20 57.6	-16 17	10.6
	16	18 25.2	-09 52	10.8	20 29.6	-16 47	10.9	10 20.0	+18 21	9.7	07 20.0	+28 59	10.2	21 09.2	-15 09	10.6
	23	18 33.1	-09 28	10.8	20 40.9	-15 54	10.8	10 15.1	+18 46	9.9	07 25.5	+28 37	10.3	21 20.6	-13 59	10.6
	30	18 40.4	-09 01	10.7	20 52.0	-14 59	10.8	10 11.5	+19 00	10.0	07 32.3	+28 12	10.5	21 31.7	-12 46	10.5
Apr	6	18 47.0	-08 33	10.6	21 02.7	-14 02	10.7	10 09.3	+19 03	10.2	07 40.2	+27 43	10.6	21 42.6	-11 30	10.5
	13	18 52.7	-08 04	10.5	21 13.2	-13 03	10.7	10 08.7	+18 56	10.4	07 48.9	+27 11	10.7	21 53.2	-10 13	10.5
	20	18 57.5	-07 35	10.3	21 23.2	-12 03	10.6	10 09.4	+18 41	10.5	07 58.4	+26 36	10.8	22 03.4	-08 54	10.4
	27	19 01.2	-07 07	10.2	21 32.8	-11 02	10.5	10 11.5	+18 18	10.7	08 08.6	+25 57	10.9	22 13.3	-07 34	10.4
May	4	19 03.9	-06 41	10.1	21 42.0	-09 59	10.4	10 14.8	+17 48	10.8	08 19.2	+25 14	11.0	22 22.9	-06 12	10.3
	11	19 05.4	-06 17	9.9	21 50.6	-08 57	10.3	10 19.1	+17 13	10.9	08 30.2	+24 29	11.1	22 32.0	-04 49	10.2
	18	19 05.6	-05 58	9.8	21 58.8	-07 54	10.2	10 24.4	+16 32	11.0	08 41.6	+23 39	11.0	22 40.7	-03 26	10.2
	25	19 04.4	-05 44	9.6	22 06.3	-06 53	10.1	10 30.5	+15 46	11.1	08 53.2	+22 47	11.2	22 48.9	-02 02	10.1
Jun	1	19 01.9	-05 37	9.4	22 13.1	-05 52	10.0	10 37.3	+14 57	11.2	09 05.0	+21 51	11.2	22 56.6	-00 38	10.0
	8	18 58.1	-05 38	9.3	22 19.2	-04 54	9.9	10 44.7	+14 04	11.3	09 16.9	+20 51	11.3	23 03.7	+00 46	9.9
	15	18 53.2	-05 48	9.1	22 24.4	-03 58	9.7	10 52.6	+13 07	11.4	09 28.9	+19 49	11.3	23 10.1	+02 09	9.8
	22	18 47.2	-06 08	9.0	22 28.7	-03 05	9.6	11 00.9	+12 08	11.5	09 41.0	+18 44	11.4	23 15.8	+03 31	9.7
	29	18 40.6	-06 39	8.8	22 31.9	-02 16	9.4	11 09.7	+11 06	11.5	09 53.2	+17 36	11.4	23 20.6	+04 51	9.5
Jul	6	18 33.6	-07 19	8.8	22 34.0	-01 33	9.2	11 18.7	+10 01	11.6	10 05.3	+16 26	11.4	23 24.5	+06 09	9.4
	13	18 26.7	-08 07	8.8	22 34.8	-00 56	9.0	11 28.1	+08 55	11.6	10 17.4	+15 13	11.4	23 27.4	+07 24	9.3
	20	18 20.4	-09 03	8.9	22 34.2	-00 27	8.8	11 37.7	+07 47	11.7	10 29.5	+13 59	11.4	23 29.0	+08 35	9.1
	27	18 15.0	-10 04	9.0	22 32.2	-00 06	8.6	11 47.5	+06 37	11.7	10 41.6	+12 43	11.4	23 29.5	+09 40	9.0
Aug	3	18 10.7	-11 09	9.1	22 28.8	+00 06	8.4	11 57.5	+05 27	11.7	10 53.7	+11 25	11.4	23 28.6	+10 39	8.8
	10	18 07.9	-12 15	9.2	22 24.1	+00 07	8.2	12 07.7	+04 15	11.7	11 05.7	+10 06	11.4	23 26.3	+11 31	8.7
	17	18 06.6	-13 20	9.4	22 18.4	-00 02	8.0	12 18.1	+03 03	11.7	11 17.7	+08 46	11.4	23 22.7	+12 12	8.5
	24	18 06.9	-14 25	9.5	22 12.0	-00 20	7.8	12 28.7	+01 50	11.7	11 29.6	+07 26	11.4	23 17.9	+12 43	8.3
	31	18 08.8	-15 27	9.6	22 05.3	-00 47	7.7	12 39.4	+00 37	11.7	11 41.5	+06 05	11.3	23 12.2	+13 01	8.2
Sep	7	18 12.2	-16 25	9.7	21 58.9	-01 20	7.8	12 50.2	-00 36	11.7	11 53.4	+04 44	11.3	23 05.8	+13 07	8.1
	14	18 17.0	-17 20	9.8	21 53.2	-01 56	8.0	13 01.1	-01 48	11.7	12 05.2	+03 23	11.3	22 59.1	+13 00	8.0
	21	18 23.2	-18 10	9.8	21 48.6	-02 32	8.1	13 12.2	-03 00	11.7	12 17.0	+02 02	11.2	22 52.7	+12 43	8.0
	28	18 30.6	-18 54	9.9	21 45.5	-03 06	8.3	13 23.4	-04 11	11.6	12 28.8	+00 42	11.1	22 47.0	+12 17	8.1
Oct	5	18 39.2	-19 34	10.0	21 44.1	-03 36	8.4	13 34.8	-05 21	11.6	12 40.6	-00 37	11.2	22 42.4	+11 45	8.2
	12	18 48.8	-20 07	10.0	21 44.5	-03 59	8.5	13 46.2	-06 29	11.5	12 52.3	-01 55	11.2	22 39.1	+11 12	8.4
	19	18 59.3	-20 34	10.1	21 46.6	-04 15	8.7	13 57.8	-07 36	11.5	13 04.0	-03 11	11.3	22 37.4	+10 39	8.5
	26	19 10.7	-20 55	10.1	21 50.4	-04 22	8.8	14 09.5	-08 40	11.4	13 15.7	-04 26	11.4	22 37.4	+10 10	8.6
Nov	2	19 22.8	-21 10	10.2	21 55.7	-04 21	8.9	14 21.2	-09 43	11.5	13 27.3	-05 38	11.5	22 38.9	+09 45	8.8
	9	19 35.6	-21 17	10.2	22 02.4	-04 11	9.0	14 33.1	-10 43	11.5	13 38.9	-06 49	11.5	22 41.9	+09 28	8.9
	16	19 49.0	-21 18	10.2	22 10.4	-03 53	9.1	14 45.0	-11 41	11.6	13 50.4	-07 57	11.6	22 46.4	+09 18	9.0
	23	20 02.9	-21 11	10.2	22 19.5	-03 27	9.2	14 57.0	-12 35	11.6	14 01.8	-09 02	11.6	22 52.1	+09 15	9.1
	30	20 17.2	-20 58	10.2	22 29.6	-02 52	9.3	15 09.1	-13 27	11.7	14 13.2	-10 05	11.6	22 59.0	+09 21	9.2
Dec	7	20 31.8	-20 37	10.2	22 40.6	-02 11	9.4	15 21.2	-14 15	11.7	14 24.4	-11 04	11.6	23 07.0	+09 34	9.3
	14	20 46.8	-20 10	10.2	22 52.3	-01 22	9.4	15 33.3	-14 59	11.7	14 35.5	-12 00	11.7	23 15.9	+09 54	9.4
	21	21 02.0	-19 36	10.2	23 04.6	-00 27	9.5	15 45.4	-15 40	11.7	14 46.4	-12 53	11.7	23 25.5	+10 21	9.5
	28	21 17.4	-18 55	10.2	23 17.6	+00 34	9.5	15 57.4	-16 17	11.7	14 57.1	-13 42	11.7	23 35.9	+10 55	9.6

MINOR PLANET POSITIONS (0hr UT, Epoch 2000.0)

		18 MELPOMENE			20 MASSALIA			25 PHOCAEA			27 EUTERPE			28 BELLONA		
		R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.	R.A.	Dec.	Mag.
		hr	min	°	hr	min	°	hr	min	°	hr	min	°	hr	min	°
Jan	5	18 18.6	-17 07	11.3	21 50.1	-12 41	11.8	15 19.5	-18 58	12.8	11 47.4	+03 15	10.8	10 42.0	+06 58	11.1
	12	18 33.0	-17 03	11.3	22 01.2	-11 43	11.8	15 33.2	-19 09	12.7	11 51.5	+02 57	10.6	10 47.0	+07 22	10.9
	19	18 47.4	-16 54	11.4	22 12.5	-10 42	11.8	15 46.9	-19 14	12.7	11 54.2	+02 50	10.5	10 42.2	+07 56	10.8
	26	19 01.9	-16 41	11.4	22 23.9	-09 38	11.7	16 00.4	-19 11	12.6	11 55.3	+02 52	10.4	10 40.3	+08 41	10.6
Feb	2	19 16.4	-16 22	11.4	22 35.5	-08 31	11.7	16 13.9	-19 00	12.5	11 54.7	+03 05	10.2	10 37.1	+09 35	10.4
	9	19 30.8	-15 58	11.4	22 47.1	-07 22	11.6	16 27.2	-18 41	12.4	11 52.6	+03 28	10.1	10 32.9	+10 36	10.2
	16	19 45.3	-15 29	11.3	22 58.8	-06 11	11.6	16 40.2	-18 12	12.3	11 48.9	+04 00	9.9	10 28.0	+11 41	10.0
	23	19 59.6	-14 55	11.4	23 10.6	-04 59	11.5	16 52.9	-17 35	12.2	11 43.9	+04 39	9.7	10 22.6	+12 48	9.9
Mar	2	20 13.9	-14 18	11.3	23 22.5	-03 44	11.5	17 05.2	-16 47	12.1	11 37.8	+05 23	9.6	10 17.3	+13 51	10.1
	9	20 28.1	-13 36	11.3	23 34.4	-02 29	11.4	17 17.0	-15 49	12.0	11 31.2	+06 08	9.3	10 12.4	+14 49	10.3
	16	20 42.2	-12 50	11.2	23 46.4	-01 12	11.2	17 28.2	-14 40	11.9	11 24.5	+06 52	9.5	10 08.2	+15 39	10.5
	23	20 56.2	-12 02	11.2	23 58.4	+00 05	11.3	17 38.8	-13 19	11.8	11 18.2	+07 31	9.7	10 05.1	+16 20	10.7
	30	21 10.0	-11 10	11.2	00 10.5	+01 23	11.3	17 48.5	-11 48	11.6	11 12.7	+08 02	10.0	10 03.3	+16 50	10.9
Apr	6	21 23.7	-10 16	11.1	00 22.6	+02 40	11.4	17 57.4	-10 04	11.5	11 08.3	+08 25	10.2	10 02.8	+17 09	11.1
	13	21 37.2	-09 20	11.0	00 34.8	+03 58	11.4	18 05.2	-08 09	11.3	11 05.3	+08 38	10.4	10 03.5	+17 19	11.2
	20	21 50.5	-08 23	11.0	00 47.0	+05 15	11.5	18 11.8	-06 02	11.1	11 03.7	+08 41	10.6	10 05.6	+17 19	11.4
	27	22 03.7	-07 25	10.9	00 59.3	+06 31	11.5	18 17.2	-03 45	11.0	11 03.6	+08 35	10.8	10 08.9	+17 10	11.5
May	4	22 16.7	-06 26	10.8	01 11.7	+07 46	11.5	18 21.1	-01 18	10.8	11 04.8	+08 21	10.9	10 13.2	+16 54	11.6
	11	22 29.5	-05 28	10.8	01 24.1	+08 59	11.5	18 23.6	+01 15	10.6	11 07.3	+07 58	11.1	10 18.6	+16 31	11.8
	18	22 42.0	-04 31	10.7	01 36.6	+10 11	11.5	18 24.4	+03 52	10.5	11 09.9	+07 29	11.3	10 24.7	+16 01	11.9
	25	22 54.3	-03 36	10.6	01 49.1	+11 21	11.5	18 23.6	+06 28	10.3	11 15.5	+06 54	11.4	10 31.6	+15 26	12.0
Jun	1	23 06.4	-02 43	10.5	02 01.7	+12 29	11.5	18 21.2	+08 58	10.2	11 21.1	+06 13	11.5	10 39.2	+14 45	12.1
	8	23 18.2	-01 54	10.4	02 14.4	+13 34	11.5	18 17.5	+11 17	10.1	11 27.3	+05 27	11.6	10 47.3	+14 00	12.1
	15	23 29.6	-01 09	10.2	02 27.0	+14 36	11.5	18 12.6	+13 18	10.0	11 34.3	+04 37	11.8	10 55.9	+13 10	12.2
	22	23 40.6	-00 30	10.1	02 39.7	+15 35	11.4	18 07.1	+14 57	10.0	11 41.9	+03 43	11.9	11 04.8	+12 17	12.3
	29	23 51.2	+00 02	10.0	02 52.4	+16 31	11.4	18 01.4	+16 10	10.0	11 49.9	+02 46	11.9	11 14.2	+11 21	12.3
Jul	6	00 01.2	+00 27	9.8	03 05.0	+17 23	11.4	17 55.9	+16 55	10.1	11 58.4	+01 47	12.0	11 23.8	+10 22	12.4
	13	00 10.6	+00 43	9.7	03 17.6	+18 12	11.3	17 51.3	+17 12	10.1	12 07.3	+00 45	12.1	11 33.6	+09 21	12.4
	20	00 19.2	+00 49	9.5	03 30.1	+18 56	11.3	17 48.0	+17 03	10.2	12 16.5	-00 19	12.2	11 43.7	+08 18	12.5
	27	00 27.0	+00 42	9.4	03 42.5	+19 37	11.2	17 46.2	+16 32	10.3	12 26.1	-01 24	12.2	11 54.0	+07 13	12.5
Aug	3	00 33.7	+00 23	9.2	03 54.7	+20 13	11.1	17 46.1	+15 42	10.4	12 35.9	-02 30	12.3	12 04.4	+06 06	12.5
	10	00 39.2	+00 11	9.0	04 06.6	+20 45	11.1	17 47.8	+14 38	10.5	12 45.9	-03 37	12.3	12 15.0	+04 59	12.6
	17	00 43.4	-01 00	8.8	04 18.2	+21 13	11.0	17 51.3	+13 22	10.6	12 56.2	-04 45	12.3	12 25.7	+03 51	12.6
	24	00 46.1	-02 04	8.6	04 29.4	+21 37	10.9	17 56.5	+12 00	10.7	13 06.7	-05 53	12.4	12 36.6	+02 43	12.6
	31	00 47.2	-03 22	8.4	04 40.2	+21 56	10.8	18 03.2	+10 33	10.8	13 17.4	-07 01	12.4	12 47.5	+01 34	12.6
Sep	7	00 46.8	-04 53	8.2	04 50.3	+22 12	10.7	18 11.5	+09 04	10.9	13 28.2	-08 08	12.4	12 58.6	+00 26	12.6
	14	00 44.9	-06 32	8.0	04 59.8	+22 24	10.6	18 21.1	+07 37	11.0	13 39.3	-09 14	12.4	13 09.7	-00 41	12.6
	21	00 41.7	-08 13	7.9	05 08.4	+22 33	10.5	18 32.0	+06 12	11.1	13 50.5	-10 20	12.4	13 20.9	-01 47	12.5
	28	00 37.8	-09 51	7.8	05 16.0	+22 39	10.3	18 43.9	+04 52	11.2	14 01.9	-11 24	12.4	13 32.2	-02 52	12.5
Oct	5	00 33.4	-11 18	7.9	05 22.5	+22 42	10.2	18 56.7	+03 39	11.3	14 13.4	-12 27	12.4	13 43.6	-03 56	12.5
	12	00 29.3	-12 30	8.0	05 27.7	+22 43	10.1	19 10.3	+02 32	11.4	14 25.1	-13 27	12.3	13 55.1	-04 58	12.4
	19	00 25.9	-13 22	8.2	05 31.4	+22 42	9.9	19 24.7	+01 33	11.5	14 36.9	-14 26	12.3	14 06.6	-05 58	12.4
	26	00 23.6	-13 52	8.4	05 33.5	+22 39	9.7	19 39.6	+00 43	11.6	14 48.8	-15 22	12.2	14 18.1	-06 55	12.4
Nov	2	00 22.7	-14 01	8.6	05 33.9	+22 35	9.5	19 54.9	+00 02	11.6	15 00.9	-16 16	12.2	14 29.7	-07 50	12.4
	9	00 23.4	-13 51	8.7	05 32.4	+22 30	9.4	20 10.7	-00 30	11.7	15 13.0	-17 07	12.1	14 41.3	-08 41	12.4
	16	00 25.6	-13 22	8.9	05 29.1	+22 24	9.2	20 26.7	-00 52	11.8	15 25.2	-17 55	12.0	14 52.9	-09 30	12.5
	23	00 29.4	-12 39	9.1	05 24.2	+22 16	9.0	20 42.8	-01 05	11.9	15 37.5	-18 39	12.1	15 04.5	-10 15	12.6
	30	00 34.6	-11 42	9.3	05 18.0	+22 07	8.8	20 59.1	-01 10	12.0	15 49.8	-19 20	12.2	15 16.0	-10 57	12.6
Dec	7	00 41.1	-10 35	9.4	05 10.8	+21 56	8.5	21 15.5	-01 06	12.0	16 02.2	-19 58	12.3	15 27.5	-11 35	12.7
	14	00 48.7	-09 19	9.6	05 03.3	+21 44	8.5	21 31.8	-00 54	12.1	16 14.5	-20 32	12.4	15 38.8	-12 09	12.7
	21	00 57.3	-07 56	9.7	04 56.2	+21 32	8.8	21 48.0	-00 35	12.2	16 26.8	-21 02	12.4	15 50.1	-12 39	12.8
	28	01 06.8	-06 28	9.8	04 49.9	+21 22	8.9	22 04.2	-00 10	12.2	16 39.0	-21 29	12.5	16 01.2	-13 05	12.8

		29 AMPHITRITE				44 NYSA				349 DEMBOWSKA				532 HERCULINA				654 ZELINDA			
Jan	5	17 30.1	-27 47	11.3		21 37.5	-15 22	12.3		22 41.1	-13 05	11.3		18 44.5	-21 10	11.0		07 31.4	+15 01	9.8	
	12	17 43.2	-27 58	11.4		21 48.5	-14 30	12.3		22 50.9	-11 50	11.3		18 57.2	-21 13	11.1		07 22.1	+13 08	9.7	
	19	17 56.2	-28 06	11.4		21 59.6	-13 35	12.3		23 00.9	-10 33	11.3		19 09.8	-21 12	11.2		07 13.1	+11 20	9.9	
	26	18 09.1	-28 10	11.4		22 10.8	-12 37	12.3		23 11.1	-09 15	11.3		19 22.3	-21 07	11.2		07 05.1	+09 42	10.1	
Feb	2	18 21.8	-28 11	11.4		22 22.1	-11 37	12.2		23 21.4	-07 56	11.3		19 34.5	-21 00	11.3		06 58.7	+08 17	10.3	
	9	18 34.3	-28 08	11.4		22 33.4	-10 34	12.2		23 31.9	-06 36	11.3		19 46.5	-20 49	11.4		06 54.4	+07 05	10.5	
	16	18 46.5	-28 03	11.4		22 44.8	-09 30	12.1		23 42.5	-05 14	11.3		19 58.3	-20 37	11.4		06 52.3	+06 07	10.7	
	23	18 58.4	-27 56	11.4		22 56.2	-08 24	12.1		23 53.2	-03 53	11.3		20 09.8	-20 23	11.4		06 52.4	+05 20	10.9	
Mar	2	19 10.0	-27 46	11.4		23 07.7	-07 17	12.0		00 04.0	-02 31	11.2		20 21.0	-20 07	11.4		06 54.7	+04 42	11.1	
	9	19 21.2	-27 35	11.3		23 19.2	-06 08	11.9		00 14.8	-01 08	11.2		20 31.8	-19 50	11.5		06 58.9	+04 12	11.3	
	16	19 31.9	-27 22	11.3		23 30.6	-04 58	12.0		00 25.7	+00 14	11.2		20 42.4	-19 33	11.5		07 04.8	+03 46	11.4	
	23	19 42.1	-27 08	11.3		23 42.1	-03 48	12.0		00 36.7	+01 36	11.1		20 52.5	-19 16	11.5		07 12.3	+03 24	11.6	
	30	19 51.8	-26 55	11.2		23 53.6	-02 38	12.1		00 47.7	+02 57	11.0		21 02.2	-18 59	11.5		07 21.0	+03 02	11.7	
Apr	6	20 00.8	-26 41	11.1		00 05.0	-01 28	12.1		00 58.8	+04 17	11.0		21 11.4	-18 44	11.5		07 30.9	+02 40	11.8	
	13	20 09.2	-26 29	11.1		00 16.5	-00 18	12.1		01 09.9	+05 36	11.1		21 20.2	-18 31	11.4		07 41.8	+02 16	11.9	
	20	20 16.9	-26 18	11.0		00 28.0	+00 52	12.1		01 21.0	+06 54	11.1		21 28.4	-18 20	11.4		07 53.4	+01 50	12.1	
	27	20 23.7	-26 09	10.9		00 39.4	+02 01	12.1		01 32.1	+08 10	11.2		21 36.1	-18 12	11.4		08 05.8	+01 20	12.2	
May	4	20 29.6	-26 03	10.8		00 50.9	+03 08	12.1		01 43.3	+09 25	11.2		21 43.1	-18 08	11.3		08 18.7	+00 47	12.3	
	11	20 34.5	-26 00	10.7		01 02.3	+04 15	12.1		01 54.5	+10 38	11.2		21 49.5	-18 09	11.3		08 32.1	+00 10	12.3	
	18	20 38.3	-26 00	10.6		01 13.7	+05 19	12.1		02 05.6	+11 49	11.3		21 55.2	-18 15	11.2		08 45.9	+00 31	12.4	
	25	20 41.0	-26 05	10.5		01 25.0	+06 22	12.1		02 16.8	+12 57	11.3		22 00.1	-18 26	11.1		09 00.0	-01 16	12.5	
Jun	1	20 42.3	-26 14	10.3		01 36.3	+07 22	12.0		02 27.9	+14 04	11.3		22 04.1	-18 44	11.1		09 14.4	-02 06	12.6	
	8	20 42.3	-26 28	10.2		01 47.6	+08 20	12.0		02 38.9	+15 07	11.3		22 07.2	-19 09	11.0		09 28.9	-02 59	12.7	
	15	20 40.9	-26 45	10.1		01 58.7	+09 15	12.0		02 49.9	+16 08	11.3		22 09.3	-19 40	10.9		09 43.6	-03 57	12.7	
	22	20 38.1	-27 05	9.9		02 09.8	+10 08	11.9		03 00.8	+17 07	11.3		22 10.3	-20 19	10.8		09 58.4	-04 57	12.8	
	29	20 34.0	-27 26	9.8		02 20.7	+10 57	11.9		03 11.5	+18 03	11.3		22 10.3	-21 05	10.7		10 13.3	-06 01	12.9	
Jul	6	20 28.6	-27 48	9.6		02 31.5	+11 42	11.8		03 22.1	+18 55	11.3		22 09.0	-21 57	10.6		10 28.3	-07 07	12.9	
	13	20 22.2	-28 09	9.4		02 42.1	+12 24	11.7		03 32.5	+19 46	11.3		22 06.7	-22 55	10.5		10 43.3	-08 16	13.0	
	20	20 15.1	-28 26	9.3		02 52.4	+13 02	11.7		03 42.7	+20 33	11.2		22 03.3	-23 56	10.4		10 58.4	-09 27	13.0	
	27	20 07.8	-28 38	9.3		03 02.4	+13 36	11.6		03 52.5	+21 18	11.2		21 58.9	-24 58	10.3		11 13.5	-10 39	13.1	
Aug	3	20 00.7	-28 44	9.5		03 12.0	+14 05	11.5		04 02.0	+22 00	11.2		21 53.7	-26 00	10.2		11 28.6	-11 53	13.1	
	10	19 54.1	-28 43	9.6		03 21.2	+14 30	11.4		04 11.1	+22 40	11.1		21 48.0	-26 59	10.2		11 43.7	-13 06	13.1	
	17	19 48.5	-28 37	9.7		03 29.8	+14 51	11.3		04 19.7	+23 18	11.1		21 42.0	-27 52	10.2		11 58.9	-14 21	13.2	
	24	19 44.2	-28 25	9.9		03 37.8	+15 07	11.2		04 27.7	+23 54	11.0		21 36.1	-28 37	10.3		12 14.1	-15 34	13.2	
	31	19 41.2	-28 08	10.0		03 45.0	+15 18	11.1		04 35.0	+24 28	10.9		21 30.5	-29 14	10.4		12 29.3	-16 47	13.2	
Sep	7	19 39.6	-27 46	10.2		03 51.4	+15 25	10.9		04 41.6	+25 00	10.9		21 25.5	-29 41	10.6		12 44.6	-17 59	13.2	
	14	19 39.6	-27 22	10.3		03 56.7	+15 27	10.8		04 47.3	+25 32	10.8		21 21.4	-29 59	10.7		12 59.9	-19 09	13.3	
	21	19 41.0	-26 55	10.4		04 00.8	+15 24	10.7		04 52.0	+26 02	10.7		21 18.4	-30 09	10.8		13 15.2	-20 17	13.3	
	28	19 43.8	-26 25	10.5		04 03.6	+15 17	10.5		04 55.6	+26 32	10.6		21 16.5	-30 09	10.9		13 30.6	-21 23	13.3	
Oct	5	19 47.8	-25 53	10.6		04 05.0	+15 06	10.3		04 57.9	+27 01	10.5		21 15.7	-30 03	11.1		13 46.0	-22 26	13.3	
	12	19 53.0	-25 19	10.7		04 04.9	+14 51	10.2		04 58.9	+27 28	10.4		21 16.1	-29 50	11.2		14 01.5	-23 27	13.3	
	19	19 59.2	-24 43	10.8		04 03.1	+14 32	10.0		04 58.5	+27 55	10.3		21 17.6	-29 31	11.3		14 17.0	-24 23	13.3	
	26	20 06.2	-24 05	10.8		03 59.7	+14 10	9.8		04 56.7	+28 20	10.2		21 20.2	-29 08	11.4		14 32.6	-25 16	13.3	
Nov	2	20 14.1	-23 24	10.9		03 54.9	+13 46	9.7		04 53.4	+28 43	10.0		21 23.7	-28 40	11.5		14 48.1	-26 05	13.2	
	9	20 22.6	-22 40	11.0		03 48.9	+13 22	9.5		04 48.7	+29 03	9.9		21 28.1	-28 08	11.5		15 03.7	-26 49	13.2	
	16	20 31.7	-21 53	11.0		03 42.1	+12 58	9.4		04 42.8	+29 18	9.8		21 33.3	-27 33	11.6		15 19.3	-27 30	13.2	
	23	20 41.3	-21 04	11.1		03 35.0	+12 37	9.4		04 36.2	+29 29	9.7		21 39.2	-26 54	11.7		15 34.8	-28 05	13.2	
	30	20 51.4	-20 11	11.1		03 28.1	+12 21	9.5		04 29.0	+29 34	9.6		21 45.6	-26 13	11.7		15 50.3	-28 35	13.3	
Dec	7	21 01.8	-19 16	11.1		03 22.0	+12 10	9.6		04 21.8	+29 33	9.6		21 52.6	-25 29	11.8		16 05.7	-29 01	13.4	
	14	21 12.5	-18 17	11.1		03 16.9	+12 07	9.7		04 15.0	+29 28	9.8		22 00.1	-24 43	11.8		16 20.9	-29 21	13.4	
	21	21 23.5	-17 15	11.1		03 13.3	+12 11	9.9		04 09.0	+29 20	9.9		22 07.9	-23 55	11.9		16 36.0	-29 36	13.5	
	28	21 34.6	-16 11	11.1		03 11.4	+12 23	10.0		04 04.1	+29 10	10.0		22 16.1	-23 05	11.9		16 50.9	-29 47	13.6	

COMETS FOR 2002

WHAT IS A COMET?

It is a member of the Solar System which is normally in a very eccentric orbit around the Sun. The orbits of periodic, or regularly reappearing, comets are quite elongated or 'egg shaped' compared to those of the planets. They also differ from the planets by being far less massive and mainly composed of water in the form of ice and dust. A common analogy is a 'dirty snowball' (admittedly a number of kilometres in diameter). The time a periodic comet takes to orbit the Sun varies greatly from comet to comet. The one with the shortest period, Encke, takes just over 3 years to orbit the Sun. There are also a number of comets that are not expected to return for hundreds of years. Each year sees the discovery of a number of new comets that have not been recorded before. The majority of these have either open-ended orbits (they are believed to be making their only visit to the Solar System and are not expected to return) or have extremely long orbital periods measured in thousands of years.

As a comet draws closer to the Sun, the nucleus or snowball heats up and the ice sublimates forming a cloud called a 'coma' around the core. The coma can be tens of thousands of kilometres in diameter. The solar wind, on its outward journey from the Sun, sweeps the coma cloud of its lightweight ionized particles forming the ion tail of the comet. This tail always points away from the Sun. The other tail that can form is a dust tail. This is made up of heavier particles that trail behind the comet along the direction of its path. The lost material from the coma will continue to be replenished from the nucleus as long as the comet stays close to the Sun. Comets do not always have tails. In fact some may only show the coma.

Comets are normally named after their discoverers (up to the first three to report the find). There are also other designations given to comets (you will see examples on the following pages). The prefix 'P/' refers to the fact the comet is periodic. The number before the 'P' indicates the number of the periodic comet. For example Comet 6P/d'Arrest indicates d'Arrest was the 6th comet confirmed to be periodic. The prefix is not assigned until the comet is found on a later return. Interestingly, Halley's Comet's prefix is 1P/ because it was the first comet shown to be periodic. In fact Halley did not find the comet. It was named after him after he successfully predicted its return. You will also see references to another naming system. It is best to explain this with an example. You will notice Comet Catalina is referred to as 'C/1999 F1'. 1999 refers to the year, F refers to the 6th half month period ('I' is not used) during the year and 1 shows it was the first discovery in this half of the month. Therefore Catalina was the first comet discovered in the second half of March 1999.

There is no such thing as a typical comet. Like people, they are all slightly different. The orbits, the overall brightness, the size of the coma and the tail can vary dramatically from comet to comet and from even return to return. To watch one brighten, develop a tail and then fade away over a period of a few weeks, can be a fascinating experience.

This section is devoted to the comets that are expected to be observable during 2002. The table (p. 124) lists these objects as well as their orbital elements. This is the data required to calculate their locations in the sky. It lists all the known comets expected to be visible that reach perihelion (closest approach to the Sun) during 2002. There are also a few included that are bright during 2002 but have a perihelion date in 2001 or 2003. The elements are followed by 'ephemerides' (a list of expected positions in the sky and magnitude estimates for different dates) for some of the brighter comets. The magnitude parameters can often be inaccurate, having been based on their behaviour on previous returns. There are also non-gravitational effects associated with comets, which can render predicted ephemerides inaccurate, especially when extrapolating orbital elements from previous returns.

Often you will read references to a comet's return being favourable (well placed) or unfavourable. There are a few factors that determine this. For example, when the comet is at its expected maximum brightness, its apparent position in the sky could have it too close to the Sun or on the opposite side of the Sun from Earth. This would likely be considered unfavourable.

Many of the comets expected in 2002 are extremely faint and would require professional size telescopes or long exposure astrophotographs to detect them. But who knows what new discoveries lie in the future! (2001 was looking a little boring until C/2001 A2 (LINEAR) exploded on the scene, see p. 41).



NOTES ON SELECTED COMETS FOR 2002 – by Greg Bryant

The monthly text in Part 1 of this book includes descriptions for comets that are faint and at low altitude. These will often be beyond the reach of many visual observers, but they are mentioned because of the tendency for comets to be anything but predictable.

Comet P/1986 A1 (Shoemaker 3): Carolyn and Eugene Shoemaker discovered this 13th magnitude comet on 10th January, 1986, on a photographic plate taken with the 0.46m Schmidt at Palomar. Observations over the next few weeks revealed that the comet was periodic, orbiting the Sun every 17 years. This is the first return of the comet since its discovery.

Comet P/1992 Q1 (Brewington): American comet hunter Howard Brewington discovered this comet, his fourth, on 28th August, 1992. By late September, it was discovered that the 11th magnitude comet was of short-period. This is the first return of Comet Brewington. Brewington has discovered a total of five comets thus far, his most recent being in 1996. Of those five comets, one was the rediscovery of a periodic comet lost since 1906, and this comet has been subsequently renamed Metcalf-Brewington.

Comet C/2000 WM1 (LINEAR): The LINEAR (Lincoln Near Earth Asteroid Research) program has discovered many objects since its inception a few years ago. The survey, largely funded by the United

States Air Force, can reach 22nd magnitude on a 2 square degree field of view in less than 100 seconds. As of mid-August 2001, 62 comets had been credited to LINEAR.

On 16th December 2000, the LINEAR team discovered an unusual asteroidal object. Follow-up observations of the object enabled it to be linked to another object detected by LINEAR on 16th and 18th November, which was designated 2000 WM1. On 20th December, the 18th magnitude object was imaged with the SAO 1.2m telescope and discovered to be a comet.

Comet LINEAR was discovered more than 5 AU from Earth and the Sun. It reaches perihelion in January 2002 at 0.56 AU from the Sun. At the time of discovery, predictions were made that the comet could reach 4th magnitude in brightness. This writer has utilised a popular 'new Oort Cloud comet' lightcurve model suggesting a peak brightness of 6th magnitude, in accordance with the predictions of some astronomers. Nevertheless, it will be a comet well worth watching from November 2001 onwards to see what eventuates.

Comet 7P/Pons-Winnecke: Jean Louis Pons, the most successful amateur comet hunter in history, discovered this comet on 12th June, 1819. Eighth magnitude at the time, the comet brightened further as

it neared both the Earth and the Sun. By late July, shortly after perihelion, it was reported to be between 5th and 6th magnitude, but immersed in twilight skies. The comet was lost from sight afterwards - a pity as in late August, it passed 0.13 AU from Earth.

Johann Encke (of Comet Encke fame) believed that Pons' comet was periodic, but although he calculated an orbital period of 5.62 years, the comet was not recovered at subsequent returns and was considered lost. In 1858, Friedrich Winnecke accidentally rediscovered the comet on 9th March as an 8th magnitude object in the morning sky. Orbital calculations within a few days of the comet's discovery revealed a similarity to Pons' comet of 1819, and this was confirmed by the time the comet was last observed in June of that year. Although the observing geometry for the comet's next return, in 1863, was very poor (and the comet was indeed missed), it was recovered at the return of 1869.

Close encounters with Jupiter have steadily increased Pons-Winnecke's orbital period and perihelion distance since 1869; from 5.59 years and 0.78 AU to 6.38 years and 1.26 AU respectively. In 1927, the comet passes just 0.04 AU from Earth (the 7th closest known approach by any comet), and displayed a brightness of better than 4th magnitude. For now, because of Pons-Winnecke's perihelion distance being somewhat greater than the extent of Earth's orbit, such close approaches can not occur. In 2062, however, the comet is predicted to pass 0.17 AU from Earth.

Comet 19P/Borrelly: Alphonse Borrelly, a comet hunter of the late 19th and early 20th centuries, discovered this comet on the night of 28th December, 1904 from Marseilles in France. Of the ten comets that bear Borrelly's name, only this one is short-period in nature. Following its discovery, the comet was widely observed during January 1905, at which time it peaked at 9th magnitude in brightness. It was observed until May of that year, and during its time, its periodic nature was revealed - perihelion was calculated to have occurred on 17th January and the orbital period was 6.9 years.

Search ephemerides calculated by G. Fayet enabled H. Knox Shaw and Alexandre Schaumasse to independently recover the comet on 20th September 1911. That return of Comet Borrelly was particularly favourable, with the comet's brightness approaching 8th magnitude. Since then, the apparitions of Borrelly have been good and bad, with an approach near Jupiter slightly altering its orbit, and locking it into a set of bad returns (period of 7 years) in the mid 20th Century. Another Jupiter encounter enabled Borrelly's period to be shortened from 7 to 6.8 years, enabling better apparitions to occur. In 1987, the comet peaked at magnitude 7.5.

During the 1994 return, the Hubble Space Telescope obtained images of the comet, and the nucleus was measured to be 8.3×3.3 km. Comet Borrelly was the target of the Deep Space 1 mission, which was launched in October 1998 and encountered the comet in September 2001 as this book was going to press. Borrelly was expected to peak at 9th magnitude around this time.

Comet 22P/Kopff: August Kopff, an astronomer who would later become director of an astronomy institute in Germany, photographically discovered this comet on 23rd August, 1906. The 12th magnitude comet was revealed to be periodic within a few weeks, although the return of 1912/13 was predicted to be too unfavourable for recovery. The subsequent return of 1919 saw the comet recovered by Max Wolf quite close to the predicted position. Since 1919, Kopff has been seen at every apparition. Its most recent return, in 1996, was extremely favourable, with the comet's closest approach to Earth (0.57 AU) occurring just days after perihelion. As a result, the comet rose to better than 8th magnitude in brightness.

46P/Wirtanen was discovered on 17th January 1948, on a photographic plate by Carl Wirtanen of Lick Observatory, whilst conducting a program of studying the proper motion of stars. The 16th magnitude comet was more than six weeks past perihelion at discovery, fading as it moved away from both Earth and the Sun. In 1954, Carl Wirtanen himself recovered the comet at its next return.

Prior to 1986, Wirtanen never became brighter than 15th magnitude, making it too faint for the amateur visual observer. However, a combination of close approaches to Jupiter in 1972 and 1984 reduced Wirtanen's perihelion distance from 1.61 AU to 1.26 AU and finally

to 1.08 AU. This enabled Wirtanen to be observed by amateurs at its returns in 1986, 1991, and 1997.

Comet Wirtanen is the target of Europe's Rosetta mission. Scheduled for launch in January 2003, the Rosetta probe will rendezvous with the comet some eight years later.

Wirtanen is also one of several periodic comets that can make close approaches to Earth. In December 2018, Wirtanen will pass less than 0.1 AU from Earth, and it should be visible to the naked-eye.

Comet 67P/Churyumov-Gerasimenko: On 20th September, 1969, Klim Churyumov examined a photographic plate taken by Svetlana Gerasimenko on 11th September at Alma-Ata Observatory in Russia during the course of a survey of comets. Churyumov identified a 13th magnitude comet that he believed was periodic comet Comas Sola, which was the target of the photograph. However, the following month, he discovered that the comet was in the wrong position for Comas Sola, and a new discovery was recognised.

Churyumov-Gerasimenko is a classic example of how Jupiter can bring new periodic comets into the inner Solar System, and into range for amateurs. In 1840, a close approach to Jupiter reduced the comet's perihelion distance from 4.0 AU to 3.0 AU, and another close approach in 1959 brought it down to 1.3 AU.

Comet 96P/Machholz 1: Donald Machholz was one of the top comet discoverers of the 1980s and 1990s, discovering nine in total, two of which were short-period in nature. This comet, his first periodic, was discovered on 12th May 1986. Brightness estimates at the time were between 10th and 11th magnitude. A parabolic orbit was calculated from observations over the first few days. In June, astronomers were very surprised to learn that the comet was in fact short-period in nature, orbiting the Sun every 5.2 years. Its exceedingly small perihelion distance, large eccentricity, and high inclination were nothing like any other member of the Jupiter family of comets.

Studies of the comet's orbit showed that it had been relatively stable for many centuries, so it became apparent that the most likely conclusion was that the comet, after having been dormant and thus undetectable for some time, had just become active. Modelling also showed that the comet's perihelion distance 1300 years ago was 0.9 AU. Today, it is 0.12 AU, and by 2450 will be as close as 0.03 AU to the Sun. Should the comet survive those increasingly close passages to the Sun, the perihelion distance will begin to move out again.

Another surprise came when the comet was observed in 1988 and 1989, around the time of aphelion when it was 5.9 AU from the Sun. Images of the stellar nucleus were brighter than expected, leading some to believe the comet was still showing some activity.

The observing window for Comet Machholz 1 is very short at each return, and this return is less favourable than most. At its last return in 1996, the comet was not visually observed by amateurs (Andrew Pearce from Western Australia reported several negative observations) but it was captured by the orbiting SOHO spacecraft around the time of perihelion - its images showed the comet at between 3rd and 4th magnitude.

Comet 116P/Wild 4: This comet was discovered by Paul Wild on 21st January 1990. The 14th magnitude object was found on a photographic plate and it was soon revealed that the comet was periodic in nature. Calculations in early February revealed that the comet had previously been in a low-eccentricity ($e = 0.17$) orbit with a perihelion distance of 3.8 AU before a close approach to Jupiter in July 1987 moved the comet much closer to the Sun.

At both its discovery apparition and its subsequent return in 1996, observers have seen the comet peak in brightness at 12th magnitude. A similar performance is expected for this return, which sees Wild 4 reach perihelion in January 2003.

BIOGRAPHICAL NOTE: Greg Bryant has been an astronomy writer, active observer, and member of the amateur astronomical community since the mid-1980s. He is publisher of the quarterly newsletter *Comet Tales* (p. 136) which provides updates on old and newly discovered comets. In 2000, he was honoured by the International Astronomical Union with the naming of minor planet (9984) Gregbryant.

COMET EPHEMERIDES 2002

EXPLANATION OF COMET EPHEMERIDES

Date is for 0 hr UT or 10am AEST (9:30am ACST) of date.
R.A., Dec Right Ascension and Declination are for equinox 2000.0
Δ (delta) Geocentric distance (distance from the Earth) in AU.
R Heliocentric distance (distance from the Sun) in AU.
Elg Elongation; angular distance of the comet from the Sun.
Mag This is the expected total magnitude of the comet. The value is only an estimate and for periodic comets it is invariably based on the behaviour of its brightness during previous return(s).

The estimate of total magnitude is normally calculated using the formula: $\text{Mag.} = H1 + 5 \log (\Delta) + K1 \log R$.

See the table of elements for the values of H1 and K1. For many comets the K1 value is equal to 10. For newly discovered comets the value of K1 is nearly always assumed to be equal to 10 until its light curve can be studied in detail. The brightness of a comet is often very uncertain; especially for those newly discovered. Comets have also been known to suddenly flare up or fade away and some have even shown a different behaviour in their light curve (changed values for H1 and K1) after perihelion compared to before. There are also constants of H2 and K2 used by astronomers which refer to the absolute magnitude and the K constant for the nucleus of the comet. These are not used in this publication.

Comet 22P/Kopff						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2002 Aug 3	12 44.3	+00 20	2.333	2.025	60	12.8
2002 Aug 10	12 56.0	-01 43	2.358	1.987	56	12.6
2002 Aug 17	13 08.3	-03 09	2.380	1.949	53	12.4
2002 Aug 24	13 21.4	-04 38	2.399	1.913	50	12.2
2002 Aug 31	13 35.2	-06 09	2.415	1.877	47	12.0
2002 Sep 7	13 49.7	-07 41	2.428	1.843	44	11.8
2002 Sep 14	14 04.9	-09 14	2.439	1.810	41	11.6
2002 Sep 21	14 20.8	-10 47	2.447	1.779	39	11.4
2002 Sep 28	14 37.5	-12 18	2.454	1.750	36	11.3
2002 Oct 5	14 54.9	-13 48	2.459	1.722	34	11.1
2002 Oct 12	15 13.1	-15 14	2.464	1.697	32	10.9
2002 Oct 19	15 32.1	-16 36	2.467	1.673	29	10.8
2002 Oct 26	15 51.8	-17 53	2.471	1.652	27	10.6
2002 Nov 2	16 12.2	-19 02	2.475	1.634	25	10.5
2002 Nov 9	16 33.3	-20 04	2.479	1.618	23	10.4
2002 Nov 16	16 55.1	-20 56	2.484	1.605	22	10.3
2002 Nov 23	17 17.3	-21 37	2.490	1.595	20	10.3
2002 Nov 30	17 40.1	-22 07	2.498	1.588	18	10.2
2002 Dec 7	18 03.1	-22 24	2.507	1.584	16	10.2
2002 Dec 14	18 26.3	-22 29	2.519	1.584	14	10.2
2002 Dec 21	18 49.6	-22 21	2.532	1.586	13	10.2
2002 Dec 28	19 12.7	-22 00	2.547	1.592	11	10.3

COMETS FOR 2002 — ORBITAL ELEMENTS (EQUINOX 2000.0)

Comet Name	Perihelion Date yy mm d.dd	q A.U.	e	Period years	ω deg	Ω deg	i deg	H1	K1
19P/Borrelly	2001 09 14.7334	1.358200	0.623896	6.9	353.3759	075.4249	030.3247	5.0	25.0
96P/Machholz 1	2002 01 08.6337	0.124105	0.958812	5.2	014.5807	094.6084	060.1866	13.0	12.0
31P/Schwassmann-Wachmann 2	2002 01 18.5163	3.408579	0.195287	8.7	018.4031	114.1943	004.5497	5.0	20.0
C/2000 WM1 (LINEAR)	2002 01 22.6656	0.555386	1.000299		276.7671	237.8988	072.5473	8.0	7.5
125P/Spacewatch	2002 01 28.0513	1.528592	0.511540	5.5	087.3013	153.2367	009.9815	13.0	15.0
6P/d'Arrest	2002 02 03.5918	1.352768	0.612809	6.5	178.1117	138.9440	019.4973	15.0	7.5
15P/Finlay	2002 02 07.1675	1.034099	0.710510	6.8	323.6382	041.9643	003.6745	12.0	10.0
C/1999 F1 (Catalina)	2002 02 13.7405	5.786986	0.998887		255.1658	020.0125	092.0300	4.0	10.0
89P/Russell 2	2002 03 22.9086	2.290067	0.397912	7.4	249.2165	042.4840	012.0279	11.5	15.0
C/2001 C1 (LINEAR)	2002 03 28.3037	5.104696	0.999785		219.9358	033.7113	068.9514	6.0	10.0
C/2000 SV74 (LINEAR)	2002 04 30.4781	3.541380	1.005072		076.2330	024.1852	075.2412	4.5	10.0
7P/Pons-Winnecke	2002 05 15.7228	1.258149	0.634076	6.4	172.2915	093.4504	022.2848	10.0	15.0
90P/Gehrels 1	2002 06 23.0188	2.965533	0.508858	14.8	028.1966	013.5283	009.6163	9.5	10.0
124P/Mrkos	2002 07 27.0306	1.467056	0.542643	5.7	181.2447	001.3902	031.3522	13.5	7.5
57P/du Toit-Neujmin-Delporte	2002 07 31.1636	1.729518	0.499103	6.4	115.2389	188.9317	002.8442	5.5	20.0
54P/de Vico-Swift	2002 08 07.4524	2.146053	0.430565	7.3	002.1374	358.9324	006.0925	10.0	15.0
67P/Churyumov-Gerasimenko	2002 08 18.3101	1.292339	0.631528	6.6	011.4520	050.9685	007.1204	11.0	10.0
46P/Wirtanen	2002 08 26.9664	1.058778	0.657885	5.4	356.4001	082.1739	011.7381	8.5	27.0
77P/Longmore	2002 09 04.7225	2.309541	0.358190	6.8	196.4466	014.9767	024.4034	9.0	14.0
18P/Perrine-Mrkos	2002 09 10.3965	1.287243	0.639515	6.8	166.6442	240.5570	017.8644	11.5	20.0
92P/Sanguin	2002 09 23.0561	1.807428	0.663372	12.4	163.0502	182.3498	018.7644	12.0	15.0
C/2001 K5 (LINEAR)	2002 10 11.9362	5.184540	1.000000		047.0686	237.4667	072.6252	2.5	10.0
26P/Grigg-Skjellerup	2002 11 29.7204	1.117878	0.632709	5.3	001.6241	211.7398	022.3473	12.0	40.0
22P/Kopff	2002 12 12.0763	1.583608	0.543307	6.5	162.7536	120.9290	004.7185	3.0	26.0
P/1986 A1 (Shoemaker 3)	2002 12 15.0206	1.813723	0.726794	17.1	014.9411	097.2704	006.3862	10.0	12.0
39P/Oterma	2002 12 21.7164	5.470734	0.244575	19.5	056.3664	331.5834	001.9432	5.0	15.0
P/1993 K2 (Helin-Lawrence)	2002 12 22.4478	3.110104	0.307738	9.5	163.6906	092.0158	009.8713	10.0	8.5
115P/Maury	2002 12 23.8741	2.041656	0.520806	8.8	119.8758	176.7557	011.6826	11.5	15.0
30P/Reinmuth 1	2002 12 24.3991	1.877508	0.502115	7.3	013.2867	119.7568	008.1306	9.5	15.0
28P/Neujmin 1	2002 12 27.3786	1.552051	0.775627	18.2	346.9190	347.0339	014.1853	11.5	6.0
116P/Wild 4	2003 01 21.7803	2.169793	0.375570	6.5	173.4160	021.0752	003.6160	2.5	25.0
P/1992 Q1 (Brewington)	2003 02 18.8430	1.590355	0.671624	10.7	048.0058	343.6435	018.0596	6.5	10.0
C/2001 HT50 (LINEAR-NEAT)	2003 07 08.7975	2.804298	1.000000		323.8007	042.8812	163.2401	4.5	10.0

Perihelion Date	Date of closest approach to the Sun.	Ω	Longitude of Ascending Node. The point of intersection between the plane of the comet's orbit and the plane of the Earth's orbit (Ecliptic) as the comet moves north.
q	The perihelion distance, in AU (Astronomical Units)	i	Inclination. Angle between the plane of the comet's orbit and the plane of the ecliptic. If the value is greater than 90°, the comets direction of orbit is retrograde i.e., moving in the opposite direction to the planets.
e	The eccentricity of the comet's orbit. Values less than one indicate a known periodic comet with an elliptical orbit. A value equal to one would indicate an open orbit which means it is a once only visitor to the Solar System, or it has a very long period (thousands of years) or the comet is newly discovered and astronomers have not clearly defined its orbit.	H1	The absolute total magnitude of the comet, which is the theoretical brightness of the comet if it was one AU from the Sun and the Earth.
Period	The comet's period in years. The time it takes to complete one orbit of the Sun.	K1	A constant used in calculating the comet's total magnitude (see 'explanation of comet ephemerides' for further details)
ω	Argument of Perihelion. The angle from the ascending node to perihelion (measured in the plane of the comet's orbit in the direction of motion of the comet).		

The maths used to calculate ephemerides from these elements is complex (but not difficult, with the power of home computers) but is beyond the scope of this publication.

Comet 7P/Pons-Winnecke						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2002 Mar 2	16 58.4	+03 43	1.202	1.538	89	13.2
2002 Mar 9	17 19.8	+03 10	1.126	1.494	90	12.9
2002 Mar 16	17 41.8	+02 34	1.055	1.453	90	12.5
2002 Mar 23	18 04.5	+01 52	0.989	1.414	91	12.2
2002 Mar 30	18 28.0	+01 02	0.928	1.379	91	11.9
2002 Apr 6	18 52.2	+00 03	0.873	1.347	92	11.6
2002 Apr 13	19 17.1	-01 07	0.823	1.319	92	11.4
2002 Apr 20	19 42.8	-02 31	0.778	1.296	92	11.1
2002 Apr 27	20 09.0	-04 09	0.740	1.279	93	10.9
2002 May 4	20 35.7	-06 02	0.707	1.266	94	10.8
2002 May 11	21 02.7	-08 09	0.680	1.259	94	10.7
2002 May 18	21 29.7	-10 29	0.658	1.258	96	10.6
2002 May 25	21 56.3	-12 60	0.643	1.263	97	10.6
2002 Jun 1	22 22.1	-15 40	0.633	1.274	99	10.6
2002 Jun 8	22 46.8	-18 25	0.628	1.290	101	10.6
2002 Jun 15	23 09.9	-21 15	0.629	1.311	103	10.8
2002 Jun 22	23 30.9	-24 06	0.633	1.337	106	10.9
2002 Jun 29	23 49.6	-26 58	0.641	1.367	109	11.1
2002 Jul 6	00 05.7	-29 48	0.653	1.401	112	11.3
2002 Jul 13	00 18.9	-32 35	0.668	1.439	116	11.5
2002 Jul 20	00 28.8	-35 18	0.687	1.479	119	11.7
2002 Jul 27	00 35.5	-37 53	0.710	1.523	123	12.0
2002 Aug 3	00 38.9	-40 17	0.736	1.568	126	12.3
2002 Aug 10	00 38.8	-42 25	0.767	1.615	130	12.5
2002 Aug 17	00 35.6	-44 12	0.803	1.664	133	12.8

Comet C/2000 WM1 (LINEAR)						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2001 Nov 3	04 25.9	+48 43	0.793	1.674	139	9.2
2001 Nov 10	03 59.7	+45 37	0.631	1.565	149	8.5
2001 Nov 17	03 21.5	+39 14	0.487	1.455	160	7.7
2001 Nov 24	02 31.2	+26 27	0.374	1.343	159	6.8
2001 Dec 1	01 33.5	+04 55	0.318	1.230	135	6.2
2001 Dec 8	00 36.8	-18 47	0.340	1.116	104	6.0
2001 Dec 15	23 47.1	-35 21	0.420	1.002	80	6.1
2001 Dec 22	23 04.7	-45 00	0.527	0.889	64	6.2
2001 Dec 29	22 26.4	-50 37	0.643	0.782	53	6.2
2002 Jan 5	21 48.6	-53 42	0.759	0.684	44	6.2
2002 Jan 12	21 09.9	-54 38	0.870	0.607	38	6.1
2002 Jan 19	20 32.9	-53 19	0.972	0.562	33	6.1
2002 Jan 26	20 03.2	-49 51	1.058	0.561	32	6.2
2002 Feb 2	19 43.7	-44 54	1.125	0.604	32	6.6
2002 Feb 9	19 33.0	-39 15	1.173	0.680	35	7.1
2002 Feb 16	19 27.7	-33 25	1.205	0.777	40	7.6
2002 Feb 23	19 25.2	-27 38	1.224	0.884	46	8.0
2002 Mar 2	19 23.9	-21 55	1.234	0.996	52	8.4
2002 Mar 9	19 22.6	-16 16	1.237	1.110	59	8.8
2002 Mar 16	19 20.8	-10 38	1.238	1.224	66	9.1
2002 Mar 23	19 17.9	-05 02	1.237	1.338	73	9.4
2002 Mar 30	19 13.6	+00 34	1.239	1.449	80	9.7
2002 Apr 6	19 07.5	+06 06	1.246	1.560	87	9.9
2002 Apr 13	18 59.4	+11 28	1.260	1.668	94	10.2
2002 Apr 20	18 49.2	+16 36	1.283	1.775	101	10.4
2002 Apr 27	18 36.9	+21 19	1.318	1.880	107	10.7
2002 May 4	18 22.6	+25 30	1.365	1.984	113	10.9
2002 May 11	18 06.7	+29 02	1.425	2.086	117	11.2
2002 May 18	17 49.9	+31 51	1.499	2.186	120	11.4
2002 May 25	17 32.8	+33 55	1.586	2.285	122	11.7
2002 Jun 1	17 16.2	+35 16	1.685	2.382	122	12.0
2002 Jun 8	17 00.9	+36 01	1.795	2.478	121	12.2
2002 Jun 15	16 47.2	+36 13	1.915	2.573	120	12.5
2002 Jun 22	16 35.6	+36 01	2.044	2.666	117	12.7

Comet 46P/Wirtanen						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2002 Jul 6	03 57.3	+13 19	1.773	1.262	44	12.5
2002 Jul 13	04 25.4	+15 10	1.727	1.216	44	12.0
2002 Jul 20	04 54.9	+16 51	1.690	1.174	43	11.5
2002 Jul 27	05 25.6	+18 17	1.662	1.138	42	11.1
2002 Aug 3	05 57.2	+19 26	1.644	1.107	41	10.8
2002 Aug 10	06 29.4	+20 14	1.634	1.083	40	10.5
2002 Aug 17	07 01.8	+20 40	1.632	1.067	40	10.3
2002 Aug 24	07 34.1	+20 44	1.639	1.060	39	10.3
2002 Aug 31	08 05.8	+20 27	1.651	1.060	38	10.3
2002 Sep 7	08 36.5	+19 49	1.670	1.069	38	10.4
2002 Sep 14	09 06.0	+18 55	1.692	1.086	38	10.6
2002 Sep 21	09 34.0	+17 47	1.717	1.111	38	10.9
2002 Sep 28	10 00.6	+16 28	1.745	1.143	38	11.3
2002 Oct 5	10 25.6	+15 03	1.772	1.180	39	11.7
2002 Oct 12	10 49.1	+13 34	1.800	1.223	40	12.1
2002 Oct 19	11 11.2	+12 04	1.826	1.270	42	12.6

Comet 57P/du Toit-Neujmin-Delporte						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2002 Mar 2	17 28.3	-21 07	2.152	2.184	79	13.9
2002 Mar 9	17 42.1	-21 06	2.042	2.149	82	13.7
2002 Mar 16	17 55.7	-20 59	1.934	2.116	86	13.4
2002 Mar 23	18 09.1	-20 47	1.828	2.083	90	13.2
2002 Mar 30	18 22.2	-20 30	1.725	2.051	94	12.9
2002 Apr 6	18 35.1	-20 08	1.624	2.019	98	12.7
2002 Apr 13	18 47.4	-19 41	1.527	1.989	102	12.4
2002 Apr 20	18 59.3	-19 11	1.434	1.960	106	12.1
2002 Apr 27	19 10.6	-18 37	1.344	1.932	110	11.9
2002 May 4	19 21.2	-18 00	1.259	1.906	114	11.6
2002 May 11	19 30.9	-17 22	1.178	1.881	118	11.3
2002 May 18	19 39.7	-16 43	1.103	1.857	123	11.1
2002 May 25	19 47.4	-16 04	1.033	1.835	128	10.8
2002 Jun 1	19 53.9	-15 27	0.968	1.815	133	10.6
2002 Jun 8	19 59.1	-14 54	0.910	1.797	138	10.4
2002 Jun 15	20 02.8	-14 25	0.859	1.781	144	10.2
2002 Jun 22	20 05.2	-14 02	0.815	1.767	149	10.0
2002 Jun 29	20 06.2	-13 47	0.778	1.755	156	9.8
2002 Jul 6	20 05.9	-13 40	0.750	1.745	162	9.7
2002 Jul 13	20 04.7	-13 41	0.730	1.738	168	9.6
2002 Jul 20	20 02.9	-13 50	0.720	1.733	173	9.6
2002 Jul 27	20 00.9	-14 05	0.718	1.730	172	9.5
2002 Aug 3	19 59.3	-14 26	0.726	1.730	167	9.6
2002 Aug 10	19 58.6	-14 48	0.742	1.732	161	9.6
2002 Aug 17	19 59.0	-15 12	0.768	1.736	154	9.7
2002 Aug 24	20 00.8	-15 33	0.801	1.743	148	9.8
2002 Aug 31	20 04.2	-15 50	0.842	1.753	142	10.0
2002 Sep 7	20 09.2	-16 03	0.890	1.764	137	10.2
2002 Sep 14	20 15.6	-16 10	0.945	1.778	131	10.4
2002 Sep 21	20 23.3	-16 10	1.006	1.794	126	10.6
2002 Sep 28	20 32.2	-16 03	1.072	1.812	122	10.8
2002 Oct 5	20 42.0	-15 48	1.144	1.831	117	11.0
2002 Oct 12	20 52.7	-15 27	1.221	1.853	113	11.3
2002 Oct 19	21 04.1	-14 58	1.303	1.876	109	11.5
2002 Oct 26	21 15.9	-14 23	1.389	1.901	105	11.8
2002 Nov 2	21 28.1	-13 42	1.479	1.927	101	12.0
2002 Nov 9	21 40.6	-12 55	1.573	1.955	97	12.3
2002 Nov 16	21 53.3	-12 02	1.670	1.984	93	12.6
2002 Nov 23	22 06.1	-11 05	1.770	2.014	89	12.8

Comet P/1992 Q1 (Brewington)						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2002 Jun 15	21 12.6	-35 53	2.172	2.942	131	12.9
2002 Jun 22	21 11.5	-36 17	2.062	2.893	137	12.7
2002 Jun 29	21 08.9	-36 42	1.961	2.844	144	12.5
2002 Jul 6	21 04.8	-37 07	1.870	2.794	150	12.3
2002 Jul 13	20 59.3	-37 28	1.790	2.745	155	12.1
2002 Jul 20	20 52.4	-37 45	1.721	2.695	159	12.0
2002 Jul 27	20 44.5	-37 53	1.665	2.646	161	11.8
2002 Aug 3	20 35.8	-37 51	1.621	2.596	160	11.7
2002 Aug 10	20 27.0	-37 36	1.590	2.546	155	11.6
2002 Aug 17	20 18.4	-37 08	1.571	2.497	150	11.5
2002 Aug 24	20 10.7	-36 27	1.563	2.448	143	11.4
2002 Aug 31	20 04.3	-35 34	1.566	2.399	136	11.3
2002 Sep 7	19 59.5	-34 32	1.577	2.350	129	11.2
2002 Sep 14	19 56.6	-33 21	1.596	2.301	123	11.1
2002 Sep 21	19 55.5	-32 05	1.621	2.253	116	11.1
2002 Sep 28	19 56.3	-30 43	1.651	2.206	110	11.0
2002 Oct 5	19 58.9	-29 19	1.683	2.159	104	11.0
2002 Oct 12	20 03.2	-27 51	1.719	2.113	99	10.9
2002 Oct 19	20 09.0	-26 20	1.755	2.067	93	10.9
2002 Oct 26	20 16.3	-24 47	1.791	2.023	88	10.8
2002 Nov 2	20 24.7	-23 10	1.827	1.980	84	10.8
2002 Nov 9	20 34.3	-21 30	1.862	1.938	79	10.7
2002 Nov 16	20 44.9	-19 46	1.896	1.897	75	10.7
2002 Nov 23	20 56.4	-17 57	1.928	1.858	71	10.6
2002 Nov 30	21 08.7	-16 03	1.959	1.821	67	10.6
2002 Dec 7	21 21.8	-14 04	1.988	1.786	64	10.5
2002 Dec 14	21 35.4	-12 00	2.015	1.753	61	10.5
2002 Dec 21	21 49.7	-09 50	2.040	1.723	57	10.4
2002 Dec 28	22 04.5	-07 35	2.064	1.695	55	10.4

Comet 96P/Machholz 1						
Date	R.A. h m	Dec °	Δ AU	R AU	Elg	Mag
2001 Dec 15	18 54.9	-45 49	1.508	0.795	28	12.7
2001 Dec 22	19 12.7	-43 50	1.353	0.624	25	11.2
2001 Dec 29	19 30.4	-40 19	1.163	0.430	21	8.9
2002 Jan 5	19 38.3	-31 37	0.932	0.206	12	4.6
2002 Jan 12	19 04.4	-12 29	0.976	0.197	12	4.5
2002 Jan 19	19 04.4	-09 31	1.231	0.422	18	9.0
2002 Jan 26	19 12.7	-09 22	1.415	0.617	22	11.2
2002 Feb 2	19 21.7	-09 35	1.556	0.788	25	12.7

METEOR SHOWERS

WHAT is a METEOR SHOWER?

A meteor shower is no more than the leftover debris from comets. A comet has been best described as a 'dirty snowball', a conglomerate of ice, frozen gases, dust and larger particles that become meteoroids when freed from the nucleus. When a comet is near perihelion, very fine dust particles are released from the nucleus as it is warmed by the Sun (by the process of sublimation). These particles are then pushed away by solar radiation or wind to form the classical dust tail of a comet. Pieces that are too large to be blown away end up strewn along the comet's orbit to become meteoroids.

Ultimately the meteoroids spread out over the comet's orbit, somewhat like an elliptical shaped donut, the effects of solar radiation and the slight gravity tugs from the planets will over time break up the stream. If the Earth passes through a meteoroid stream we will experience a meteor shower. A typical meteor of visual magnitude may be as small as a grain of sand up to the size of a small pea. Particles in space that strike the Earth's atmosphere will have a minimum speed of 11 km/s (if the body is at rest when swept up by the Earth), and an upper limit of 73 km/s. The Leonid stream, at 71 km/s, makes it the fastest of the showers.

Incredible velocities such as these (a bullet from a rifle travels at about 1 km per second) result in the meteor's kinetic energy being converted to heat when it strikes the atmosphere at an altitude of about 100 km. The surrounding air is heated to incandescence by friction and as a consequence we can observe these tiny bodies as they self-destruct in our atmosphere.

Individual meteors during a shower appear to originate from a common point in the sky known as the radiant. This focal point is named after the constellation in which the meteors appear or the comet that is associated with the shower. Members of meteoroid streams travel through space in parallel paths. The apparent divergence from the radiant is only an illusion, due simply to the effect of perspective. The way that trees and buildings converge on either side of a long straight road, is the same effect that is seen when a meteor shower occurs far above an observer.

The table of Meteor Showers has been compiled from the 'Meteor Shower Calendar' produced by the International Meteor Organisation (IMO). It is the most accurate listing for naked-eye meteor observing available today. The table is complete in that both northern and southern showers are listed. Serious meteor observing should be carried out under dark skies, and preferably without the Moon. The best showers for this year, taking into consideration the lunar phase, are summarised in the monthly section.

In addition to the showers catalogued, an average of about 5 to 10 sporadic meteors (originating from random points in the sky) are visible per hour under dark sky conditions. More meteors are seen in the morning sky than in the evening; as the morning sky is facing the Earth's motion in space we tend to 'run into' and 'sweep up' meteors, whereas evening meteors must have sufficient velocity to catch up to the speeding Earth. Amateurs wishing to follow up an interest in meteors, and even make a contribution to meteor science, should

SHOWER NAME	MOON PHASE	ACTIVITY DURATION	MAX ACT	RADIANT		DIA	VEL km/s	ZHR
				R.A.	Dec			
Quadrantids	LQ	Jan 01-Jan 05	Jan 03	230°	+49°	5°	41	120
delta-Cancerids	FQ	Jan 01-Jan 24	Jan 17	130°	+20°	10°-5°	28	4
alpha-Centaurids	NM	Jan 28-Feb 21	Feb 08	210°	-59°	4°	56	6
delta-Leonids	FQ	Feb 15-Mar 10	Feb 24	168°	+16°	5°	23	2
gamma-Normids	NM	Feb 25-Mar 22	Mar 13	249°	-51°	5°	56	8
Virginids	FQ	Jan 25-Apr 15	Mar 24	195°	-04°	15°-10°	30	5
Lyrids	FQ	Apr 16-Apr 25	Apr 21	271°	+34°	5°	49	15
pi-Puppids*	FQ	Apr 15 - Apr 28	Apr 23	110°	-45°	5°	18	*
eta-Aquarids	LQ	Apr 19-May 28	May 05	338°	-01°	4°	66	60
Sagittarids	FQ	Apr 15-Jul 15	May 19	247°	-22°	15°-10°	30	5
Bootids (June)*	FM	Jun 26 - Jul 02	Jun 27	224°	+48°	5°	18	*
Pegasids	NM	Jul 07-Jul 13	Jul 09	340°	+15°	5°	70	3
Phoenicids (July)*	NM	Jul 10 - Jul 16	Jul 13	032°	-48°	7°	47	*
Pisces Austrinids	FM	Jul 15-Aug 10	Jul 28	341°	-30°	15°-10°	35	5
Southern delta-Aquarids	FM	Jul 12-Aug 19	Jul 28	339°	-16°	5°	41	20
alpha-Capricornids	LQ	Jul 03-Aug 15	Jul 30	307°	-10°	8°	23	4
Southern iota-Aquarids	LQ	Jul 25-Aug 15	Aug 04	334°	-15°	5°	34	2
Northern delta-Aquarids	NM	Jul 15-Aug 25	Aug 08	335°	-05°	5°	42	4
Perseids	FQ	Jul 17-Aug 24	Aug 12	046°	+58°	5°	59	140
kappa-Cygnids	FQ	Aug 03-Aug 25	Aug 17	286°	+59°	6°	25	3
Northern iota-Aquarids	FM	Aug 11-Aug 31	Aug 19	327°	-06°	5°	31	3
alpha-Aurigids	LQ	Aug 25-Sep 05	Sep 01	084°	+42°	5°	66	10
delta-Aurigids	NM	Sep 05-Oct 10	Sep 08	060°	+47°	5°	64	6
Piscids	FM	Sep 01-Sep 30	Sep 19	005°	-01°	5°	26	3
Draconids*	NM	Oct 06 - Oct 10	Oct 08	262°	+54°	2°	20	*
Epsilon Geminids	FM	Oct 14-Oct 27	Oct 18	102°	+27°	5°	70	2
Orionids	FM	Oct 02-Nov 07	Oct 21	095°	+16°	10°	66	20
Southern Taurids	NM	Oct 01-Nov 25	Nov 05	052°	+13°	10°-5°	27	5
Northern Taurids	FQ	Oct 01-Nov 25	Nov 12	058°	+22°	10°-5°	29	5
Leonids	FM	Nov 14-Nov 21	Nov 17	153°	+22°	5°	71	100+
alpha-Monocerotids	FM	Nov 15-Nov 25	Nov 21	117°	+01°	5°	65	Var
chi-Orionids	NM	Nov 26-Dec 15	Dec 02	082°	+23°	8°	28	3
Phoenicids	NM	Nov 28-Dec 09	Dec 06	018°	-53°	5°	18	Var
Puppids-Velids	NM	Dec 01-Dec 15	Dec 07	123°	-45°	10°	40	10
Monocerotids (Dec)	FQ	Nov 27-Dec 17	Dec 09	100°	+08°	5°	42	3
sigma-Hydrids	FQ	Dec 03-Dec 15	Dec 11	127°	+02°	5°	58	2
Geminids	FQ	Dec 07-Dec 17	Dec 14	112°	+33°	5°	35	120
Coma Berenicids	FM	Dec 12-Jan 23	Dec 19	175°	+25°	5°	65	5
Ursids	FM	Dec 17-Dec 26	Dec 22	217°	+76°	5°	33	10

contact the International Meteor Organisation. They can be reached on the Web: www.imo.net/ or by writing to Ina Rendtel, IMO Treasurer, Mehlerbeerenweg 5, D-14469 Potsdam, Germany. You can also email to treasurer@imo.net for details on IMO membership. Please enclose return postage if writing. International Reply Coupons are available from Australia Post outlets.

NOTES ON THE TABLE ABOVE

SHOWER NAME The shower is named after the constellation that the radiant appears in or a bright star near that point. A shower marked with an asterisk (*) is only occasionally active.

MOON PHASE The phase of the Moon nearest the date of maximum activity. If a Full Moon occurs near a shower's maximum period, only the very brightest of meteors will be seen.

ACTIVITY DURATION The approximate dates when the shower is active.

MAX ACT The date when maximum activity can be expected.

RADIANT, R.A. & Dec: The position of the shower radiant in right ascension and declination (R.A. is expressed in degrees). These co-ordinates refer to the radiant position on the date of maximum activity.

DIA The radiant diameter. When two figures are given, the first is the spread in R.A. and the second the spread in Dec.

VEL km/s The apparent velocity through the atmosphere in kilometres per second. The range can be from about 11km/s (very slow) to 71km/s (very fast), medium speed is about 40km/s.

ZHR Zenith Hourly Rate, a theoretical rate assuming the radiant to be at the zenith with a sky limiting magnitude of 6.5 (perfect conditions).

PART III - APPENDICES

BRIGHTEST AND NEARER STARS (p. 128)

The column descriptions are:

Designation The name of the star in the system created by Bayer. He numbered the stars in the constellations using Greek letters (p. 144). They were ordered by their brightness, alpha being the brightest in most cases.

Name Common names for the stars.

Constellation The star's constellation.

RA and Dec. The position of the star, epoch 2000.0.

Magnitude App. The apparent magnitude as seen in the sky.

Magnitude Abs. The absolute magnitude. This is a good indication of how the stars' true luminosities compare. It is the brightness of the star if placed at a distance of 10 parsecs (approximately 32.6 light years) from Earth.

Spectral Type The spectral classification of the star (see below).

Parallax see glossary.

ly is light year and **pc** is parsec (see glossary).

The spectral type of a star gives a broad indication of its temperature and colour. The primary classes are **O, B, A, F, G, K** and **M**, remembered by the mnemonic **Oh Be A Fine Girl(Guy) Kiss Me**. There are also now the 'colder' star classes, **L** and **T**. The classes are then broken down into ten subclasses (1 to 10) and then even further subdivided into I, II, III, IV, etc. A discussion of these is beyond this publication.

- The **O** class stars are the hottest blue stars.
- **B** and **A** are white (e.g., Sirius, Rigel)
- **G** and early **K** (subclass <5) are yellow (e.g., Capella, the Sun and Arcturus)
- Late **K** (subclass >5) and **M** stars are the cooler red stars (e.g., Aldebaran, Betelgeuse).

It is interesting trying to see the colour in stars, but it is worthwhile knowing the limitations of the human eye. The photosensitive part of the eye is the retina. It consists of two types of light receptors, rods and cones. The cones perceive colour and rods see only in shades of grey. The cones only work when there is sufficient light. Starlight, to the unaided eye, activates rods and cones to different degrees. Faint stars are only seen as grey (i.e., no colour).

The colours of stars can be simply photographed. Mount your normal 35mm camera on a tripod and take a time exposure (some minutes) using a fast film. The resulting star trails often show the colours very well. An equatorially tracked time exposure (e.g., piggybacked on a telescope) with the camera slightly out of focus results in nicely coloured discs of the brightest stars. If in focus, the colour of the brightest stars can be lost as their images burn out on the negative. All such photography should be conducted in country areas, away from city lights.

NON-STELLAR OBJECTS (p. 129)

The term 'Non-Stellar Object' refers to either clusters of stars, galaxies or nebulae (which include dark, bright and planetary nebulae).

Clusters of Stars can be anything from a collection of a few stars, close together (open star clusters), up to the massive collection of millions of stars (globular star clusters). Some globulars are so dense that the central regions, as seen through moderately sized telescopes, remain as cloudy blobs which are unable to be resolved into individual stars. 47 Tucanae is a good example.

Galaxies are the largest scale structures in the Universe, consisting of a collection of hundreds of billions of stars. The Milky Way and the two Clouds of Magellan (SMC and LMC) are the brightest examples of galaxies. They are all visible to the unaided eye providing you are under dark skies.

Nebulae are enormous clouds of gas that quite often mark the remains of a dead star (e.g., the Crab Nebula) or the birthplace of future stars (e.g., the Orion Nebula). Clouds of gas that do not glow are sometimes visible as shadows against the Milky Way. A good example of these dark nebulae is the Coal Sack which is clearly visible next to the Southern Cross.

The column descriptions are:

CAT and NUM. Is the catalogue and the number of the object. NGC stands for New General Catalogue and IC, Index Catalogue.

RA and DEC. This is the position of the object in the sky in Right Ascension and Declination (Epoch 2000.0)

SIZE. The object's size expressed in arc minutes.

CON. Is the standard three letter abbreviation for the constellation the object is in (see table below).

TYPE. Is the broad classification as discussed above.

MAG. This is the brightness of the object expressed in magnitude. As these deep sky dwellers are large, compared to the pinpoint stars, the magnitude is expressed as if all the light from the object was compressed into a small 1 arc second square. This raises an interesting point. If the object is bright, it could still be quite faint and hard to locate if it is large. The light is spread out over a larger area and its surface brightness could be low. This is particularly important for galaxies. Therefore, when looking for a new galaxy, check its size before going to the telescope.

DESCRIPTION. This includes Messier numbers, common names and a general description.

CONSTELLATIONS - Abbreviations and Culmination at 9pm.

Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.	Name	Genitive	Abr.	Cul.
Andromeda	Andromedae	And	Nov 23	Cygnus	Cygni	Cyg	Sep 13	Pavo	Pavonis	Pav	Aug 29
Antlia	Antliae	Ant	Apr 10	Delphinus	Delphini	Del	Sep 14	Pegasus	Pegasi	Peg	Oct 16
Apus	Apodis	Aps	Jul 05	Dorado	Doradus	Dor	Jan 31	Perseus	Persei	Per	Dec 22
Aquarius	Aquarii	Aqr	Oct 09	Draco	Draconis	Dra	Jul 08	Phoenix	Phoenicis	Phe	Nov 18
Aquila	Aquilae	Aql	Aug 30	Equuleus	Equulei	Equ	Sep 22	Pictor	Pictoris	Pic	Jan 30
Ara	Arae	Ara	Jul 25	Eridanus	Eridani	Eri	Dec 25	Pisces	Piscium	Psc	Nov 11
Aries	Arietis	Ari	Dec 14	Fornax	Fornacis	For	Dec 17	Piscis Austrinus	Piscis Austrini	PsA	Oct 09
Auriga	Aurigae	Aur	Feb 04	Gemini	Geminorum	Gem	Feb 19	Puppis	Puppis	Pup	Feb 22
Bootes	Bootis	Boo	Jun 16	Grus	Gruis	Gru	Oct 12	Pyxis	Pyxidis	Pyx	Mar 21
Caelum	Caeli	Cae	Jan 15	Hercules	Herculis	Her	Jul 28	Reticulum	Reticuli	Ret	Jan 03
Camelopardus	Camelopardi	Cam	Feb 06	Horologium	Horologii	Hor	Dec 25	Sagitta	Sagittae	Sge	Aug 30
Cancer	Cancri	Cnc	Mar 16	Hydra	Hydrae	Hya	Apr 29	Sagittarius	Sagittarii	Sgr	Aug 21
Canes Venatici	Canum Venaticorum	CVn	May 22	Hydrus	Hydri	Hyi	Dec 10	Scorpius	Scorpii	Sco	Jul 18
Canis Major	Canis Majoris	CMa	Feb 16	Indus	Indi	Ind	Sep 26	Sculptor	Sculptoris	Scl	Nov 10
Canis Minor	Canis Minoris	CMi	Feb 28	Lacerta	Lacertae	Lac	Oct 12	Scutum	Scuti	Sct	Aug 15
Capricornus	Capricorni	Cap	Sep 22	Leo	Leonis	Leo	Apr 15	Serpens	Serpentis	Ser	Jul 21
Carina	Carinae	Car	Mar 17	Leo Minor	Leonis Minoris	LMi	Apr 09	Sextans	Sextantis	Sex	Apr 08
Cassiopeia	Cassiopeiae	Cas	Nov 23	Lepus	Leporis	Lep	Jan 28	Taurus	Tauri	Tau	Jan 14
Centaurus	Centauri	Cen	May 14	Libra	Librae	Lib	Jun 23	Telescopium	Telescopii	Tel	Aug 24
Cepheus	Cephei	Cep	Nov 13	Lupus	Lupi	Lup	Jun 23	Triangulum	Trianguli	Tri	Dec 07
Cetus	Ceti	Cet	Nov 29	Lynx	Lyncis	Lyn	Mar 05	Triangulum Australe	Trianguli Australis	TrA	Jul 07
Chamaeleon	Chamaeleontis	Cha	Apr 15	Lyra	Lyrae	Lyr	Aug 18	Tucana	Tucanae	Tuc	Nov 01
Circinus	Circini	Cir	Jun 14	Mensa	Mensae	Men	Jan 28	Ursa Major	Ursae Majoris	UMa	Apr 25
Columba	Columbae	Col	Feb 01	Microscopium	Microscopii	Mic	Sep 18	Ursa Minor	Ursae Minoris	UMi	Jun 27
Coma Berenices	Comae Berenices	Com	May 17	Monoceros	Monocerotis	Mon	Feb 19	Vela	Velorum	Vel	Mar 30
Corona Australis	Coronae Australis	CrA	Aug 14	Musca	Muscae	Mus	May 14	Virgo	Virginis	Vir	May 26
Corona Borealis	Coronae Borealis	CrB	Jul 03	Norma	Normae	Nor	Jul 03	Volans	Volantis	Vol	Mar 04
Corvus	Corvi	Crv	May 12	Octans	Octantis	Oct	Circum	Vulpecula	Vulpeculae	Vul	Sep 08
Crater	Crateris	Crt	Apr 26	Ophiuchus	Ophiuchi	Oph	Jul 26				
CruX	Crucis	Cru	May 12	Orion	Orionis	Ori	Jan 27				

THE BRIGHTEST STARS

See introduction to Part III (p. 127) for more information.

Designation		Name	Constellation	R.A. (2000.0)	Dec (2000.0)	Magnitude App. Abs.		Spectral Type	Parallax	Distance ly pc		
1		Sun				-26.70	4.8	G2 V				
2	α	CMa	Sirius	Canis Major	06 45.2	-16 43	-1.46	1.4	A1 V	0.375	8.7	2.67
3	α	Car	Canopus	Carina	06 23.9	-52 42	-0.72	-8.5	F0 Ia	0.018	180	55.21
4	α	Cen	Rigel Kent	Centaurus	14 39.6	-60 50	-0.10	4.4	G2 V	0.751	4.3	1.32
5	α	Boo	Arcturus	Bootes	14 15.7	+19 11	-0.04	-0.2	K2 IIIp	0.090	36	11.04
6	α	Lyr	Vega	Lyra	18 36.9	+38 47	0.03	0.5	A0 V	0.123	26	7.98
7	α	Aur	Capella	Auriga	05 16.7	+46 00	0.08	0.4	G8 III	0.073	45	13.80
8	β	Ori	Rigel	Orion	05 14.5	-08 12	0.12	-7.1	B8 Ia	0.004	815	250.00
9	α	CMi	Procyon	Canis Minor	07 39.3	+05 14	0.38	2.6	F5 IV	0.288	11	3.37
10	α	Eri	Achernar	Eridanus	01 37.7	-57 14	0.46	-1.6	B5 IV	0.023	142	43.56
11	α	Ori	Betelgeuse	Orion	05 55.2	+07 24	v0.50	-5.6	M2 Iab	0.005	650	199.39
12	β	Cen	Hadar	Centaurus	14 03.8	-60 22	0.61	-5.1	B1 II	0.008	400	122.70
13	α	Aql	Altair	Aquila	19 50.8	+08 52	0.77	2.2	A7 IV-V	0.198	16	4.91
14	α	Tau	Aldebaran	Taurus	04 35.9	+16 31	0.85	-0.3	K5 III	0.048	68	20.86
15	α	Cru	Acrux	Crux	12 26.6	-63 06	0.87	-3.9	B1 IV	0.012	270	82.82
16	α	Sco	Antares	Scorpius	16 29.4	-26 26	0.96	-4.7	M1 Ib	0.008	400	122.70
17	α	Vir	Spica	Virgo	13 25.2	-11 10	0.98	-3.5	B1 V	0.012	270	82.82
18	β	Gem	Pollux	Gemini	07 45.3	+28 02	1.14	0.2	K0 III	0.093	35	10.74
19	α	PsA	Fomalhaut	Piscis Austrinus	22 57.7	-29 37	1.16	2.0	A3 V	0.144	23	7.06
20	α	Cyg	Deneb	Cygnus	20 41.4	+45 17	1.25	-7.5	A2 Ia	0.002	1600	490.80
21	β	Cru	Becrux	Crux	12 47.7	-59 41	1.25	-5.0	B0 III	0.007	460	141.10
22	α	Leo	Regulus	Leo	10 08.4	+11 58	1.35	-0.6	B7 V	0.039	85	26.07
23	ϵ	CMa	Adhara	Canis Major	06 58.6	-28 58	1.50	-4.4	B2 II	0.005	650	199.39
24	α	Gem	Castor	Gemini	07 34.6	+31 53	1.58	1.2	A1 V	0.072	46	14.11
25	λ	Sco	Shaula	Scorpius	17 33.6	-37 06	1.63	-3.0	B2 IV	0.010	300	92.02
26	γ	Cru	Gacrux	Crux	12 31.2	-57 07	1.63	-0.5	M3 III	0.015	88	26.99
27	γ	Ori	Bellatrix	Orion	05 25.1	+06 21	1.64	-3.6	B2 III	0.011	300	92.02
28	β	Tau	Alnath	Taurus	05 26.3	+28 36	1.65	-1.6	B7 III	0.018	180	55.21
29	β	Car	Miaplacidus	Carina	09 13.2	-69 43	1.68	-0.6	A0 III	0.031	85	26.07
30	ϵ	Ori	Alnilam	Orion	05 36.2	-01 12	1.70	-6.2	BO Ia	0.003	1206	369.94

THE NEARER STARS

No	Star Name		Constellation	R.A. 2000 hh mm.m	Dec ° ' "	Magnitude Apparent Absolute		Spect Type	Parallax ' "	Proper Motion	Distance ly pc	
1	Sun					-26.70	4.80	G2				
2	Proxima Centauri		Centaurus	14 29.7	-62 41	11.09	15.50	M5	0.772	3"82	4.23	1.30
3	Alpha Centauri	A	Centaurus	14 39.6	-60 50	0.01	4.40	G2	0.750	3"70	4.35	1.33
		B				1.34	5.70	K0				
4	Barnard's Star		Ophiuchus	17 57.8	+04 42	9.55	13.20	M4	0.545	10"37	5.98	1.83
5	Wolf 359		Leo	10 56.5	+07 01	13.45	16.60	M6	0.418	4"69	7.80	2.39
6	Lalande 21185		Ursa Major	11 03.4	+35 58	7.47	10.50	M2	0.395	4"82	8.23	2.52
7	UV Ceti (L726-8)	A	Cetus	01 39.0	-17 57	12.41	15.30	M6	0.381	3"37	8.57	2.63
		B				13.20	16.10	M6				
8	Sirius	A	Canis Major	06 45.2	-16 43	-1.43	1.50	A1	0.380	1"33	8.57	2.63
		B				8.40	11.30	DA2				
9	Ross 154		Sagittarius	18 49.8	-23 50	10.47	13.10	M4	0.341	0"72	9.56	2.93
10	Ross 248		Andromeda	23 41.9	+44 11	12.29	14.80	M6	0.316	1"63	10.33	3.17
11	Epsilon Eridani		Eridanus	03 32.9	-09 28	3.73	6.20	K2	0.306	0"98	10.67	3.27
12	Ross 128		Virgo	11 47.8	+00 48	11.12	13.50	M4	0.301	1"35	10.83	3.32
13	L 789-6	ABC	Aquarius	22 38.5	-15 18	12.33	14.70	M5	0.294	3"26	11.08	3.40
14	BD +43°44 (Groombridge 34)	A	Andromeda	00 18.4	+44 01	8.08	10.40	M1	0.290	2"91	11.27	3.46
		B				11.07	13.40	M4				
15	Epsilon Indi		Indus	22 03.4	-56 47	4.68	7.00	K5	0.289	4"71	11.29	3.46
16	61 Cygni	A	Cygnus	21 06.9	+38 45	5.22	7.50	K5	0.289	5"23	11.30	3.47
		B				6.03	8.30	K7				
17	BD +59°1915	A	Draco	18 42.9	+59 38	8.90	11.20	M3	0.286	2"27	11.40	3.50
		B				9.68	12.00	M4				
18	Tau Ceti		Cetus	01 44.1	-15 56	3.50	5.80	G8	0.286	1"92	11.40	3.50
19	Procyon	A	Canis Minor	07 39.3	+05 14	0.38	2.70	F5	0.286	1"24	11.41	3.50
		B				10.70	13.00	F5				
20	Lacaille 9352		Piscis Austrinus	23 05.9	-35 51	7.34	9.60	M2	0.284	6"90	11.47	3.52
21	GJ 1111		Cancer	08 29.8	+26 47	14.79	17.00	M7	0.276	1"29	11.83	3.63
22	GJ 1061		Horologium	03 36.0	-44 31	13.03	15.20	M6	0.270	0"84	12.06	3.70
23	YZ Ceti (L725-32)		Cetus	01 12.5	-17 00	12.05	14.20	M5	0.267	1"35	12.20	3.74
24	Luyten (BD + 5°1668)		Canis Minor	07 27.4	+05 14	9.86	12.00	M4	0.264	3"76	12.34	3.79
25	Lacaille 8760		Microscopium	21 17.3	-38 52	6.67	8.70	M0	0.259	3"45	12.61	3.87
26	Kapteyn's Star		Pictor	05 11.6	-45 01	8.84	10.90	M0	0.258	8"65	12.63	3.87

NON-STELLAR OBJECTS (Epoch 2000.0)

See introduction to Part III (p. 127) for more information.

CAT	NUM	R.A.	DEC	SIZE	CON	TYPE	MAG	DESCRIPTION
NGC	55	00 14.9	-39° 11'	30'x6.3'	Scl	Spiral galaxy	8.1	A bright galaxy in the Sculptor Group
NGC	104	00 24.1	-72° 05'	30.9'	Tuc	Globular cluster	3.8	47 Tucanae, one of the finest globulars
NGC	224	00 42.7	+41° 16'	185'x75'	And	Spiral galaxy	3.4	M31, The 'Andromeda Galaxy'
NGC	253	00 47.6	-25° 17'	30'x6.9'	Scl	Spiral galaxy	7.6	'Silver Coin' galaxy. Large, bright edge-on spiral
SMC	00 52.7	-72° 30'	5°x4°		Tuc	Galaxy	2.3	Small Magellanic Cloud. Visible to unaided eye from dark sky
Pleiades	03 47.0	+24° 07'	2°		Tau	Open cluster	1.2	M45 or 'Seven Sisters'. Naked eye cluster, the brighter stars mag. 2
Hyades	04 27.0	+16° 00'	6°		Tau	Open cluster	0.5	A naked eye, 'V' shaped cluster. 28 stars, the brighter mag. 3 and 4
LMC	05 23.6	-69° 45'	9°x10°		Dor	Galaxy	0.1	Large Magellanic Cloud. Visible to unaided eye from dark sky
NGC	1976	05 35.4	-05° 27'	65'x60'	Ori	Gaseous nebula	4.0	M42, 'Orion Nebula', emission and reflection nebula
NGC	2070	05 38.6	-69° 05'	30'x20'	Dor	Emission nebula	8.3	30 Doradus, 'Tarantula Nebula', bright complex looped structure
NGC	2169	06 08.4	+13° 57'	6'	Ori	Open cluster	5.9	Rich loose cluster, 30 stars magnitude 7 and fainter
NGC	2168	06 08.9	+24° 20'	28'	Gem	Open cluster	5.3	M35, 200 stars, magnitude range 9 to 16, no central concentration
NGC	2244	06 32.4	-04° 52'	23'	Mon	Open cluster	4.8	Rich cluster of 100 stars, with nebulosity (Rosette Nebula)
NGC	2264	06 41.1	+09° 53'	20'	Mon	Open cluster	3.9	40 stars, large brightness range, involved in nebulosity (Cone Nebula)
NGC	2287	06 47.0	-20° 44'	38'	CMa	Open cluster	4.5	M41, 80 stars 7th magnitude and fainter with 6.9 mag. red star near centre
NGC	2301	06 51.8	+00° 28'	12'	Mon	Open cluster	6.0	Rich cluster, 80 stars, large magnitude range, central concentration
NGC	2362	07 18.8	-24° 57'	8'	CMa	Open cluster	4.1	60 stars, large brightness range (4th mag. down), concentrated centre
NGC	2422	07 36.6	-14° 30'	29'	Pup	Open cluster	4.4	M47, large coarse cluster with 30 bright and faint stars
NGC	2437	07 41.8	-14° 49'	27'	Pup	Open cluster	6.1	M46, rich open cluster, 100 stars, planetary nebula NGC2438 in same field
NGC	2447	07 44.6	-23° 52'	22'	Pup	Open cluster	6.2	M93, 80 stars magnitude 8 to 13 with strong central concentration
NGC	2451	07 45.4	-37° 58'	45'	Pup	Open cluster	2.8	Rich in stars with slight central concentration
NGC	2477	07 52.3	-38° 33'	27'	Pup	Open cluster	5.8	160 stars around 10 - 12th magnitude, strong central concentration
NGC	2516	07 58.3	-60° 52'	29'	Car	Open cluster	3.8	80 stars 6th magnitude and fainter, strong central concentration
NGC	2547	08 10.7	-49° 16'	74'	Vel	Open cluster	4.7	Rich in stars with strong central concentration. Brightest stars mag. 6
NGC	2548	08 13.8	-05° 48'	54'	Hya	Open cluster	5.8	M48, Large cluster of 80 stars 8 to 13th magnitude, central concentration
NGC	2632	08 40.1	+19° 59'	95'	Cnc	Open cluster	3.1	M44, 'Praesepe' or 'Beehive Cluster', very large cluster, 50 stars
IC	2391	08 40.2	-53° 04'	50'	Vel	Open cluster	2.5	Moderately rich in bright (about mag. 3) and faint stars
IC	2395	08 41.1	-48° 12'	7'	Vel	Open cluster	4.6	40 stars 6th magnitude and fainter
NGC	2808	09 12.0	-64° 52'	13.8'	Car	Globular cluster	6.1	Large and rich, compressed centre, stars 13 to 15th magnitude
NGC	3114	10 02.7	-60° 07'	35'	Car	Open cluster	4.2	Rich cluster, stars 9 to 14th magnitude, slight central concentration
NGC	3132	10 07.1	-40° 26'	30"	Vel	Planetary nebula	9.7	The 'Eight Burst Nebula', ring and disk, 10th magnitude central star
IC	2602	10 43.2	-64° 24'	50'	Car	Open cluster	1.9	Rich in stars, strong central concentration, brightest stars mag. 3
NGC	3372	10 43.8	-59° 52'		Car	Emission nebula		The 'Eta Carinae Nebula', very bright, prominent dark lanes
NGC	3532	11 06.4	-58° 40'	55'	Car	Open cluster	3.0	Rich and large, slight central concentration, 150 stars 7 to 12th magnitude
NGC	3766	11 36.1	-61° 37'	12'	Cen	Open cluster	5.3	Rich cluster, 100 stars magnitude range 7 to 12th
NGC	4755	12 53.6	-60° 20'	10'	Cru	Open cluster	4.2	The 'Jewel Box', rich in stars, large brightness range
NGC	4945	13 05.4	-49° 28'	23'x5.9'	Cen	Spiral galaxy	9.0	Large edge on spiral, good field, another small galaxy in same field
NGC	5128	13 25.5	-43° 01'	31'x23'	Cen	Galaxy	6.7	'Centaurus A', bright sphere crossed by dark lane, radio source
NGC	5139	13 26.8	-47° 29'	36'	Cen	Globular cluster	3.5	Omega Centauri, perhaps the finest example of a globular cluster
NGC	5272	13 42.2	+28° 23'	16.2'	CVn	Globular cluster	5.9	M3, large bright globular, brightens suddenly towards the middle
NGC	5281	13 46.6	-62° 54'	5'	Cen	Open cluster	5.9	40 stars, moderately rich in bright and faint stars, magnitudes 6 to 12
NGC	5617	14 29.8	-60° 43'	10'	Cen	Open cluster	6.3	80 stars, large brightness range, strong central concentration
NGC	5904	15 18.6	+02° 05'	17.4'	Ser	Globular cluster	5.7	M5, bright, large very compressed in middle, slightly oval in shape
NGC	6025	16 03.7	-60° 30'	12'	TrA	Open cluster	5.1	60 stars, large brightness range, slight central concentration
NGC	6067	16 13.2	-54° 13'	12'	Nor	Open cluster	5.6	100 stars, large brightness range, strong central concentration
NGC	6087	16 18.9	-57° 54'	12.5'	Nor	Open cluster	5.4	40 stars, moderate brightness range, slight central concentration
NGC	6121	16 23.6	-26° 32'	26.3'	Sco	Globular cluster	5.8	M4, conspicuous globular near Antares
NGC	6124	16 25.6	-40° 40'	29'	Sco	Open cluster	5.8	100 stars, large brightness range, strong central concentration
NGC	6193	16 41.3	-48° 46'	14'	Ara	Open cluster	5.2	Few stars, large brightness range, slight central concentration
NGC	6205	16 41.7	+36° 28'	16.6'	Her	Globular cluster	5.7	M13, the 'Great Hercules Cluster', showpiece of northern skies
NGC	6231	16 54.0	-41° 48'	14'	Sco	Open cluster	2.6	A few stars with strong central concentration. Brightest stars mag. 5
NGC	6405	17 40.1	-32° 13'	33'	Sco	Open cluster	4.2	M6, the 'Butterfly Cluster', 80 stars, large brightness range
NGC	6397	17 40.7	-53° 40'	25.7"	Ara	Globular cluster	5.8	Loose, scattered structure, possibly the nearest of the globulars
NGC	6475	17 53.9	-34° 49'	80'	Sco	Open cluster	3.2	M7, 80 stars brighter than 10th magnitude, large brightness range
NGC	6494	17 56.8	-19° 01'	27'	Sgr	Open cluster	5.5	M23, 150 stars, moderate brightness range, lies in good star field
NGC	6514	18 02.3	-23° 02'	20'	Sgr	Gaseous nebula	5.0	M20, 'Trifid Nebula', emission and reflection nebulosity cut by dark lanes
NGC	6523	18 03.8	-24° 23'	45'x30'	Sgr	Emission nebula	5.0	M8, 'Lagoon', densest section known as the 'Hourglass', dark lane
NGC	6611	18 18.8	-13° 47'	21'	Ser	Open cluster	6.0	M16, 100 bright and faint stars, involved in the 'Eagle Nebula'
IC	4725	18 31.6	-19° 15'	32'	Sgr	Open cluster	4.6	M25, 30 stars loosely scattered
NGC	6656	18 36.4	-23° 54'	24'	Sgr	Globular cluster	5.1	M22. Fine globular, only Omega Centauri and 47 Tucanae are brighter
NGC	6705	18 51.1	-06° 16'	13'	Sct	Open cluster	5.8	M11, the 'Wild Duck Cluster', rich and compact open cluster
NGC	7009	21 04.2	-11° 22'	25"	Aqr	Planetary nebula	8.5	The 'Saturn Nebula', ring structure in a larger and fainter halo
NGC	7078	21 30.0	+12° 10'	12.3'	Peg	Globular cluster	6.0	M15, bright, irregularly round, well resolved into faint stars
NGC	7293	22 29.6	-20° 48'	12'	Aqr	Planetary nebula	7.3	The 'Helix Nebula', ring structure involved in larger and fainter disk

RISE/SET TIME CORRECTIONS FOR OTHER LOCATIONS

As mentioned previously in this book, the rise/set tables for the Sun, Moon and planets, in Part II, are calculated for Adelaide, Brisbane, Canberra, Darwin, Hobart, Melbourne, Sydney and Townsville.

This page is designed to help people, who live outside of these cities, to make corrections to determine the rise/set times for their specific location. There are two corrections needed, they are:

1. An adjustment for the difference in longitude. **For every degree of longitude east or west of SYDNEY, subtract or add respectively 4 minutes to both the rise and set times.** Examples of corrections for various towns/cities are given in table 1.
2. An adjustment for the difference in latitude also requires the declination for the object of interest. Table 2 presents these corrections (southern latitudes are negative). NB. **for rise times you add these values, for set you subtract.** For your specific latitude it is normally sufficient to interpolate these figures.

It is IMPORTANT that Rise/Set times for SYDNEY are used, IRRESPECTIVE of which town in Australia the calculations are for, when using these tables.

In all these calculations it is easier to first convert all latitudes and longitudes to decimal degrees.

Example of rise/set time corrections.

Calculate the rise/set times for the Sun on January 19 for Albury (36° 05'S, 146° 55'E)

	Rise	Set
From p.81 the rise/set values for Sydney are:	5:03	19:08
Adjust for longitude (151.25-146.92)*4 (table 1)	+ :17	+ :17

(value is positive due to Albury being west of Sydney)

Adjust for latitude & Declination of Sun from - :05 + :05

table 2 (Dec. = -20° 25' p. 82)

Rise/Set times for Albury are: 5:15 19:30

NB. If your local time is Australian Central Standard time, **subtract** 30 minutes.

If daylight saving is in force, **add** 60 minutes.

TABLE 1

LONGITUDE ADJUSTMENTS FOR SOME TOWNS AND CITIES RELATIVE TO SYDNEY

Location	Latitude (° ' S)	Longitude (° ' E)	Change in Longitude (decimal °)	correction (mins.)
NSW				
Albury	36 05	146 55	4.3	17
Bathurst	33 25	149 34	1.7	7
Broken Hill	32 0	141 27	9.8	39
Coffs Harbour	30 13	153 08	-1.9	-8
Dubbo	32 15	148 37	2.6	11
Eden	37 01	149 56	1.3	5
Gosford	33 26	151 21	-0.1	0
Goulburn	34 45	149 43	1.5	6
Katoomba	33 42	150 18	0.9	4
Newcastle	32 55	151 45	-0.5	-2
Parkes	33 05	148 10	3.1	12
Tamworth	31 03	151 02	0.2	1
Wagga Wagga	35 05	147 20	3.9	16
Wollongong	34 25	150 52	0.4	2
NORTHERN TERRITORY				
Alice Springs	23 42	133 56	17.3	69
Ayers Rock	25 11	130 58	20.3	8
Tennant Creek	19 34	134 08	17.1	68
QUEENSLAND				
Bundaberg	24 52	152 21	-1.1	-4
Cairns	16 55	145 49	5.4	22
Longreach	23 22	144 09	7.1	28
Mackay	21 08	149 10	2.1	8
Mount Isa	20 38	139 28	11.8	47
Rockhampton	23 21	150 28	0.8	3
Surfers Paradise	28 00	153 26	-2.2	-9
Toowoomba	27 33	151 58	-0.7	-3
Townsville	19 10	146 49	4.4	18
TASMANIA				
Launceston	41 20	147 08	4.1	16
Stanley	40 40	145 08	6.1	24
VICTORIA				
Ballarat	37 25	143 55	7.3	29
Benalla	36 30	146 01	5.2	21
Bendigo	36 46	144 17	7.1	28
Geelong	38 09	144 10	7.1	28
Morwell	38 12	146 21	4.9	20
Shepparton	36 13	145 25	5.8	23
Swan Hill	35 13	143 30	7.8	31
Wangaratta	36 17	146 13	5.0	20
Warnambool	38 27	142 30	8.8	35
SOUTH AUSTRALIA				
Port Augusta	32 30	137 52	13.4	54
Port Lincoln	34 42	135 59	15.3	61
Mount Gambier	37 41	140 49	10.4	42
Whyalla	33 02	137 34	13.7	55

TABLE 2 - RISE/SET CORRECTIONS FOR LATITUDE/DECLINATION (from Sydney)

		Declination												
South Latitude (negative)	30°	25°	20°	15°	10°	5°	0°	-5°	-10°	-15°	-20°	-25°	-30°	
	-12°	-63	-50	-39	-28	-19	-9	0	9	19	28	39	50	63
	-14°	-58	-46	-36	-26	-17	-8	0	8	17	26	36	46	58
	-16°	-53	-42	-33	-24	-16	-8	0	8	16	24	33	42	53
	-18°	-48	-38	-29	-22	-14	-7	0	7	14	22	29	38	48
	-20°	-43	-34	-26	-19	-13	-6	0	6	13	19	26	34	43
	-22°	-37	-30	-23	-17	-11	-5	0	5	11	17	23	30	37
	-24°	-32	-25	-19	-14	-9	-5	0	5	9	14	19	25	32
	-26°	-26	-20	-16	-11	-7	-4	0	4	7	11	16	20	26
	-28°	-20	-16	-12	-9	-6	-3	0	3	6	9	12	16	20
	-30°	-13	-11	-8	-6	-4	-2	0	2	4	6	8	11	13
	-32°	-7	-5	-4	-3	-2	-1	0	1	2	3	4	5	7
	-34°	0	0	0	0	0	0	0	0	0	0	0	0	0
	-36°	8	6	5	3	2	1	0	-1	-2	-3	-5	-6	-8
	-38°	16	12	9	7	4	2	0	-2	-4	-7	-9	-12	-16
	-40°	25	19	15	10	7	3	0	-3	-7	-10	-15	-19	-25
	-42°	34	26	20	14	9	5	0	-5	-9	-14	-20	-26	-34
	-44°	44	34	26	18	12	6	0	-6	-12	-18	-26	-34	-44

JULIAN DATE — 2002

To calculate Julian Date (JD), first convert local time to Universal Time (UT); subtract 10 hrs from AEST, 9.5 hrs from ACST, correcting the date if necessary. Next find the Julian date given in the table (below left) for the month you are interested in. Now add the day of the month. This will give you JD for 0hrs UT on the date in question. Then add the fraction of day from the second table (below right) that matches the time you are calculating for.

Example: you wish to know the Julian date at 23:00 AEST on July 17th. Subtract 10 hours to get UT.

$$23 - 10 = 13:00 \text{ hrs UT}$$

From the table the JD for July is 2452455.5

Add the day of month, 17 gives us 2452472.5

Now add the hours as a fraction of a day from the 2nd table. 13hr is 0.542. Thus JD at 23:00hr 17 July 2002 AEST is 2452473.042

JULIAN DATE at 0hrs UT		Hours as decimal of a day.			
Month	Julian Date				
Jan 0	2452274.5	01	0.042	13	0.542
Feb 0	2452305.5	02	0.083	14	0.583
Mar 0	2452333.5	03	0.125	15	0.625
Apr 0	2452364.5	04	0.167	16	0.667
May 0	2452394.5	05	0.208	17	0.708
Jun 0	2452425.5	06	0.250	18	0.750
Jul 0	2452455.5	07	0.292	19	0.792
Aug 0	2452486.5	08	0.333	20	0.833
Sep 0	2452517.5	09	0.375	21	0.875
Oct 0	2452547.5	10	0.417	22	0.917
Nov 0	2452578.5	11	0.458	23	0.958
Dec 0	2452608.5	12	0.500	24	1.000

SIDEREAL TIME — 2002

Greenwich mean sidereal time at 0hrs UT

Jan 0	6.6327	Jul 0	18.5262
Feb 0	8.6697	Aug 0	20.5632
Mar 0	10.5096	Sep 0	22.6002
Apr 0	12.5466	Oct 0	0.5715
May 0	14.5179	Nov 0	2.6085
Jun 0	16.5549	Dec 0	4.5798

You can use the following method to calculate Local Mean Sidereal Time. First convert your local time and date to U.T. Now calculate the Greenwich mean sidereal time (GMST) for that date.

GMST on day d of month at hour t U.T.

$$= \text{GMST at 0h UT (from table above)} + 0.06571 d + 1.00274 t$$

To convert this to Local mean sidereal time (LMST) we use

$$\text{LMST} = \text{GMST} + \text{east longitude (or - west longitude)}$$

where longitude is expressed in HOURS (not degrees!)

To convert longitude from degrees to hours, just divide by 15.

Example:

Find LMST at 23:00 hours Sydney time (AEST) on 17th July 2002.

$$23:00 \text{ AEST} = 13:00 \text{ UT}$$

GMST for July 0 is 18.5262 hours.

$$\text{GMST} = 18.5262 + (0.06571 \times 17) + (1.00274 \times 13) = 32.6789$$

Sydney's longitude is 151.25° which is 10.0833 hrs so

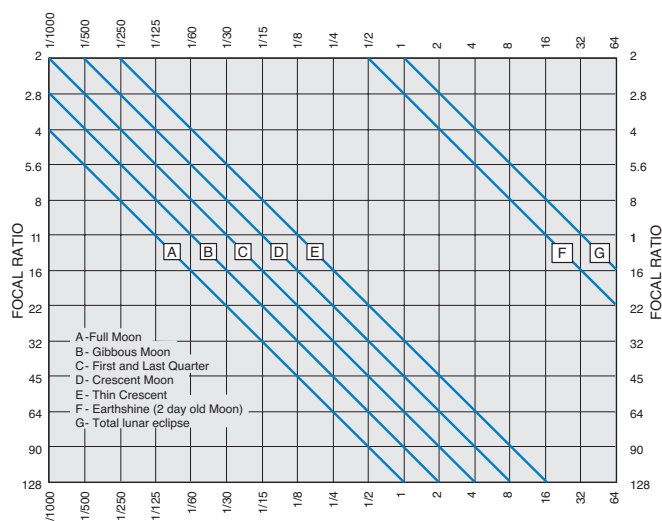
$$\text{LMST} = 32.6789 + 10.0833 = 42.7622$$

Subtract from or add to this multiples of 24 until it is in the range of 0 to 24

$$42.7622 - 24 = 18.7622 \text{ hrs or } 18\text{h } 45\text{m } 44\text{s}$$

PHOTOGRAPHIC EXPOSURE GUIDES

MOON

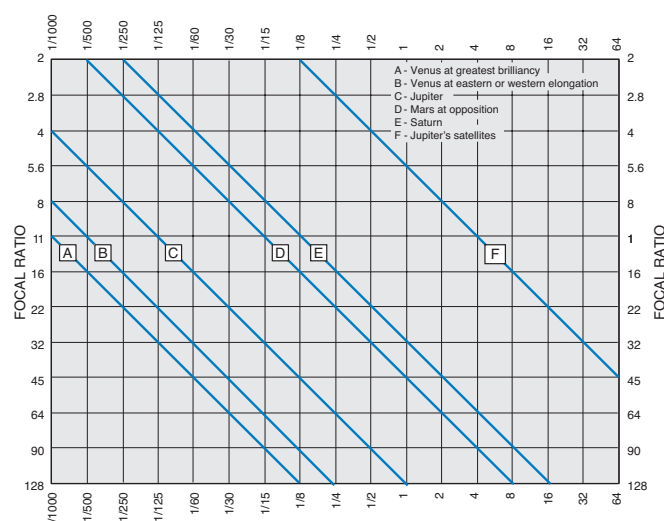


These charts provide recommended photographic exposures for the Moon (left) and selected planets (right) using 100 ISO film. The charts should only be treated as a guide as many factors will influence the exposure time.

Follow a horizontal line nearest to your systems focal ratio to the oblique line that represents the Moon aspect or planet required, then follow the intersecting vertical line down to find the correct exposure.

For the best result always take one photo at the recommended speed and follow up with one at half and one at twice the exposure (bracketing). This will help smooth out variables and should provide at

PLANETS



least one image at the required density.

Film Speed	Multiply By	Film Speed	Divide By
32 ISO	4	200 ISO	2
64 ISO	2	400 ISO	4

For ISO values other than 100 the above factors should be applied to the exposure time.

Places of Astronomical Interest

Following is a list of places of astronomical interest. These facilities cater to the public in regards to tours and/or displays. Prices are subject to change. Links to all of the web sites listed in the following Places, Courses and Societies sections can be found on the Quasar Publishing site (www.quasarastronomy.com.au)

NEW SOUTH WALES & ACT

THE AUSTRALIA TELESCOPE - NARRABRI ARRAY

The Australia Telescope operates in the radio region of the spectrum. It essentially uses high technology to combine the signals from a number of dishes, or elements, to obtain the performance of a single theoretical dish a number of kilometres in diameter. The Compact Array, located at the CSIRO's Paul Wild Observatory near Narrabri, is the heart of the telescope. It consists of six 22m dishes five of which are spaced along a 3km track with the sixth a further 3 km to the west. The Tidbinbilla Tracking Station and Parkes Radio Telescope are also equipped to form part of the long baseline array. Also on the ATNF site at Narrabri is the Sydney University Stellar Interferometer (SUSI) which is described in the display at the visitor's centre. From the visitor's centre there are great views of the dishes and an excellent display and video tape presentation.

Hours: 8am to 4pm daily (not staffed weekends, except school holidays).

Cost: No charge for the centre. Bookings are appreciated for groups.

Contact: Tim Kennedy (02) 6790-4070.

Email: tkennedy@atnf.csiro.au

Web: wwwnar.atnf.csiro.au

GROVE CREEK OBSERVATORY

This observatory is located 60km south of Bathurst. The facility caters for amateur astronomers and groups who are looking for very dark skies and excellent seeing conditions. The facility boasts a Celestron C-14, two 12.5" Newtonians and a Meade 10" LX-200 which include full astrophotography and CCD equipment. Grove Creek Observatory has modern on-site accommodation, sleeping up to 10 people with full facilities available.

cost: \$120 per person/per night all inclusive (conditions apply).

contact: Steven Williams on (02) 6368-8611 or (02) 9438-1757

Email: info@gco.org.au

Web: www.gco.org.au

DARBY FALLS OBSERVATORY

The observatory is located on Observatory Road (off the road to Mt. McDonald) Darby Falls, Cowra. It offers one of the largest telescopes accessible to the public, a 500mm Newtonian. Also available are 400mm, 300mm and 200mm instruments. They have a flat screen planetarium.

Times: Winter: 7-10pm, Summer: 8.30-11pm, or by appointment. Coaches and schools welcome.

Contact: Mark Monk (02) 6345-1900 or fax (02) 6345-1920

Email: darbysob@tpg.com.au

GILGANDRA OBSERVATORY

The Gilgandra Observatory is in the centre of town, just off the Newell Highway, opposite the Three Ways Motel. It has operated since 1975 providing a 12.5" f/6 newtonian reflector for the public to view the heavens. Guided tours of the night sky are held each night except Sundays (during school holidays it is also open Sunday nights and during the day, noon till 4pm). It pays to book ahead to avoid disappointment.

Times: 7pm to 10pm (daylight saving 8:30pm to 10pm)

Cost: Adults \$8, pensioners \$6, children \$5, family \$20.

Contact: (02) 6847-2646 fax: (02) 6847-2845

Email: mail@gilobs.com.au

Web: www.gilobs.com.au

DUBBO OBSERVATORY

Dubbo's 'Star Attraction' is located next to the world renowned Western Plains Zoo. Stage one of the observatory is running, which includes 3 x 300 mm Schmidt Cassegrain telescopes and 2 pairs of 30 x 70 binoculars. At this dark site, you will have the opportunity to scan the Milky Way through these binoculars or tour the skies with the computerised telescopes. Slides of the Universe, displays, videos and a well stocked gift shop are available.

Cost: Adults \$13.50; family of four \$38.50 concession, school groups, tour groups and interested amateur astronomers.

Address: 13L Camp Rd. P.O.Box 308 Dubbo NSW 2830.

Email: dubbobs@hwy.com.au

Hours: Open daily (except Christmas) from 10 a.m. until late.

Bookings essential for night sessions.

Contact: Peter Neilson (manager) (02) 6885-3022 Fax (02) 6885-3012

Web: www.hwy.com.au/~dubbobs/

GREEN POINT OBSERVATORY

The observatory is operated by the Sutherland Astronomical Society (SAS) in Sydney. The two observatory buildings house a 41cm reflector and a 35cm C14 SCT. The Society also has a 15cm f/12 refractor and several smaller telescopes. Visitors are most welcome. The observatory is open on every Thursday night. The society also runs regular open nights which are very popular with the general public. In 2002, open nights are tentatively scheduled for First Quarter Moon weekends in August. Contact the SAS (p. 140) for details.

THE CANBERRA SPACE DOME & OBSERVATORY

The Canberra Space Dome (Planetarium) is a virtual reality star theatre that uses special effects to take you on a cosmic adventure through the Universe. Experience perfect night sky simulations, interplanetary space flight, and discover the mysteries of the night sky. Shows are tailored to educate and entertain. The Observatory features research-grade telescopes under domes and is one of the finest public observatories in Australia. Sessions are conducted by professional astronomers and explainers.

Address: Hawdon Place (off Antill St) Dickson, ACT

Open: Tuesday - Saturday evenings (phone for session times)
Bookings essential.

Cost: per facility: \$8.50-adult, \$6.00-child / student / senior,
\$24.00-family (2 adults + 2 children, extra child \$4 each)

Contact: Phone: (02) 6248-5333 Fax: (02) 6249-7238

Email: planetarium@ctuc.asn.au

Web: www.ctuc.asn.au/planetarium/

KOOLANG OBSERVATORY AND SPACE SCIENCE CENTRE

Located on the border of the Central Coast, Lower Hunter and Wyong, the centre is no more than 2 hours from most Sydney and Newcastle suburbs. Koolang's 0.5 metre and other telescopes are in operation 7 days and nights a week. Bookings are essential. Over 10,000 students have visited the observatory during the last 6 years and Koolang staff have developed curriculum and theme based presentations to cover all school years from infants through to year 12. Support material is available.

Hours: Daytime solar viewing shows and display centre visits 6 days (closed Wednesday), 10am to 1pm and 3pm to 5pm. Night shows (2 hours) - Friday and Saturday nights (7 nights for groups.) Night shows start about an hour after sunset. Starting times vary, and booking is essential.

Cost: Public night shows: adults \$11; concession; \$9.50; child \$8. Day shows: Adults \$5; concession \$4; children \$3; Group (15 or more) discounts available. Special prices and hours for schools. These prices may change slightly.

Contact: (02) 4998-8216, fax (02) 4998-8580

Email: michael@koolang.com.au

Web: www.koolang.com.au

NEPEAN OBSERVATORY

The Nepean Observatory is on the Werrington North campus of the University of Western Sydney Nepean, near Penrith. The main telescope is a 24 inch (600 mm) used for both public viewing and research. The Observatory is open every Friday night (except between Christmas and New Year) for star gazing, astronomy talks and slide shows. Sessions commence at 7pm (7.30pm during daylight saving). Group bookings taken for other nights of the week.

Cost: Adults \$8.80, child / concession \$4.40, family \$19.80

Contact: (02) 9678-7524

Email: r.mccourt@uws.edu.au

Web: www.uws.edu.au/astronomy/observatory/observatory.html

PARKES RADIO TELESCOPE

The observatory is located on the western plains of NSW, twenty kilometres north of Parkes (just off the Newell Highway). This landmark radio telescope is just over 40 years old, but still considered to be one of the best single dish radio telescopes in the world. It also functions as part of the CSIRO Australia Telescope Array. As well as a great view of the telescope, its visitor's centre has doubled in size, upgraded its displays, beautified its grounds and added a 3-D audio visual 'The Sun what a Star' to compliment the flag-ship presentation 'The Invisible Universe'. There is also a freely available public picnic area, with a large shelter and gas barbecue facility. Souvenirs and educational material are available (including mail order).

Hours: 8:30am to 4:30pm - daily except Christmas & Boxing Day.

Cost: Admission to the visitor's centre is free. A modest charge is made for the audio visual presentations.

Contact: (02) 6861-1777

Email: rtwardy@atnf.csiro.au

Web: www.parkes.atnf.csiro.au/visitors_centre/

BIG BADJA OBSERVATORY (NUMERALLA)

Situated on a dark site 20 km east of Cooma, the 3.4m domed observatory houses a 25cm Meade SC telescope on a Losmandy mount. Objectives include developing CCD imaging skills and expanding community awareness about current astronomical events. Instruction is freely offered in the use of telescopes and accessories. Small groups are welcome by appointment and asked to make a donation direct to the Fred Hollows Foundation. Open most suitable evenings throughout the year.

Contact: Robert McDonald (02) 6453-3221

WOLLONGONG SCIENCE CENTRE AND PLANETARIUM



Operated by the University of Wollongong, this public science centre includes a planetarium, observatory, laser light shows, extensive indoor and outdoor hands-on exhibition areas, demonstration theatre, and a gift & resource shop, retailing astronomical materials as well as general science items. The BHP Star Theatre seats 70 and has a state of the art Zeiss ZKP3 star projector. The Duke Energy Observatory houses a computer controlled DFM telescope under a large dome which is used for solar as well as stellar observations.

Cost: Child \$5.50, concession \$7, adult \$9

Hours: 10am to 4pm, 7 days. Bookings are also available out of hours and there are scheduled astronomy evenings.

Address: Science Centre, Squires Way, Wollongong NSW 2522

Contact: (02) 4286-5000, fax: (02) 4283-6665

Web: www.uow.edu.au/science_centre

KINGS TABLELAND OBSERVATORY (BLUE MOUNTAINS)

The observatory is located at Wentworth Falls. It is at an altitude of 930 metres which makes it a high and dark site, while still close to Sydney. The facility is open to any interested people or groups. Two modern telescopes are available for use; both housed in a 4.5 metre dome. The observatory also conducts classes for the Nepean Community College which includes: workshops on the night sky, use of star charts, astrophotography and instructions on the use of telescopes. There is also a flat screen planetarium.

Hours: Flexible to meet demand.

Contact: Roger North, Sybil Barber (02) 4757-2954

Email: north.barber@bigpond.com

CANBERRA DEEP SPACE COMMUNICATION COMPLEX (TIDBINBILLA)

The Complex is located 40km southwest of Canberra (Tourist Drive 5). The Tidbinbilla Complex is a major link in NASA's Deep Space Network, playing an essential role in communicating with NASA's interplanetary robotic spacecraft. The Complex sends and receives radio signals from distant spacecraft as they explore the bodies in our Solar System: the planets and their moons, asteroids, comets and the Sun. The centrepiece of the Complex is the 70 metre antenna, the largest steerable antenna in the Southern Hemisphere. The visitor centre incorporates audio and visual displays, interactive exhibits, models and images from the spacecraft.

Hours: 9am to 5pm, 7 days per week (8pm daylight saving time).

Cost: There is no charge for the Space Centre.

Contact: (02) 6201-7880

Email: cdsc-prc@anbe.cdsc.nasa.gov

Web: www.cdsc.nasa.gov/

BOWEN MOUNTAIN OBSERVATORY

This observatory is operated by the Astronomical Society of NSW. It is located on Bowen Mountain near North Richmond (north west of Sydney). It houses a 40cm Dobsonian telescope. The observatory is open on Friday and Saturday nights (not every week). Visitors are welcome.

Contact: Adrian Saw (02) 4572-1568

MACQUARIE UNIVERSITY OBSERVATORY

Located on the Macquarie University Campus at North Ryde, this observatory is open to the public several nights a week. With a range of telescopes for use by visitors, the observatory offers great views of the heavens. Intending visitors should ring the observatory for further information on times and charges.

Contact: (02) 9850-8914

Web: www.southernskies.com.au/macqu.htm

SIDING SPRING OBSERVATORY

The Warrumbungle National Park indeed makes a magnificent setting for this world class observatory. It is situated 25 kilometres west of Coonabarabran. The most prominent feature is the tall white dome of the Anglo-Australian Telescope (AAT). The 3.9 metre instrument is still the 'flag-ship' for optical astronomy in this country. Siding Spring Mountain is also home for a number of other telescopes such as the Australian National University's (ANU) 0.4m, 0.6m, 1.0m and the 2.2m Advanced Technology Telescope (ATT). The 1.2m Schmidt Camera is also located on the mountain. For the public there is a viewing gallery for the AAT. The visitor's centre or 'Siding Spring Exploratory' consists of the 'Exploring the Universe' exhibition.

Hours: 9:30am to 4:00pm daily except Christmas Day.

Cost: \$5.50 adults, \$3.50 children/concession and \$13.50 family. Special tours can be arranged for buses or school groups. During NSW school holidays a 1.5 hour tour is available, conducted by an astronomer. They run daily, ring for details. Cost is \$9 seniors/children, \$11 adult, \$27 family.

Contact: (02) 6842-6211.

email: juls@mso.anu.edu.com.au

Web: www.aao.gov.au/

SETTLERS FLAT LODGE - COUNTRY RETREAT WITH OBSERVATORY

Settlers Flat Lodge is a four star guesthouse situated 14km east of Braidwood. The lodge features seven ensuite rooms, tennis court, full size billiard table and an observatory facility. The observatory instruments include Celestron C14 and C8 telescopes, plus an 8" f/7 Dobsonian.

Prices for accommodation include dinner, bed & breakfast, with sky tour (please enquire). Bookings essential. The observatory and sky tour costs \$5 (\$10 including a light supper).

Address: 112 Charleys Forest Road, Mongarlowe Via Braidwood

Contact: Carolyn or Noel Matthews (02) 4842-8085

fax (02) 4842-8003

Email: settlers@sci.net.au

Web: www.settlersflat.com.au

MAGELLAN OBSERVATORY



This facility is situated on 120 acres at Lake Bathurst which is in the Southern Tablelands of NSW, 30km south of Goulburn. This well equipped observatory has accommodation and a variety of telescopes which includes a computerised 46cm New Generation Telescope (NGT18) housed in a 4.5m dome. An astrophotography rig is also available for hire. The accommodation is a two bedroom house which is a short walk from the observatory. For those travelling by train, your hosts Zane & Fiona Hammond will even pick you up from Goulburn station.

Address: Lot 48 Covan Creek Rd Lake Bathurst 2580

Contact: (02) 4849-4489

Email: magellan@goulburn.net.au

Web: www.goulburn.net.au/~magellan

SYDNEY OBSERVATORY

The observatory is located in a park just a short walk from the historic Rocks district of Sydney, near the southern end of the Harbour Bridge. Since the Powerhouse Museum took over the observatory, it has had a renewed interest in public education. The centre offers a more hands-on approach for visitors, with a number of displays and films on astronomy. On weekends, visitors are invited to observe the Sun - safely (weather permitting). Night time tours include observations of the Moon and planets through the observatory's historic and modern telescopes. There is also an exhibition called 'By the light of the Southern Stars'.

Hours: 10am to 5pm, except Christmas Day. Night sessions are held every night of the week. Bookings required for evening tours.

Cost: Evening sessions - \$10 adults, \$5 students or concession and \$25 for families. There is no charge for daytime visits.

Contact: (02) 9217-0485

Web: www.phm.gov.au/observe/

PORT MACQUARIE OBSERVATORY

This is operated by the Port Macquarie Astronomical Association. It is open to the public on Wednesday & Sunday evenings at 7.30 pm (8.15pm, daylight savings). Lectures are given on the Solar System and Universe plus viewing of celestial objects. Special opening nights can be arranged for organised groups. The Observatory is situated in Rotary Park which is opposite Town Beach, Port Macquarie. They own two Celestron telescopes.

Address: Port Macquarie Astronomical Association Inc,

P. O. Box 1453,

Port Macquarie NSW 2444

Contact: Jim Daniel (02) 6583-1933 or Peter Hall (02) 6586-1095

Email: jaidanl@bigpond.com.au

Organised Adult Education Classes are held at the Observatory,

Contact: Dave Reneke (02) 6585-2260.

MT. STROMLO OBSERVATORY

Mt Stromlo is the oldest fully operational research observatory in Australia, and the closest active optical observatory to a capital city anywhere in the world. The observatory is operated by the ANU, and, together with the university's dark sky observatory at Siding Spring, near Coonabarabran, is an international leader in optical astronomy. Mt Stromlo Observatory Visitors' Centre (formerly called Stromlo Exploratory) is full of exciting interactive exhibits to make astronomy come alive for all ages. A heliostat allows visitors to safely view sunspots on the Sun's surface, and displays include a chunk of the Henbury meteorite. Professional astronomers and explainers conduct hourly slide shows and tours of the massive 74" reflector. Other telescopes date back to 1868 and include the 50" (the former Great Melbourne Telescope), 30" Reynolds and Yale-Columbia refractor. Astronomers also run regular public observing nights (phone for details). School or special interest groups of 10 or more can visit at night by appointment. Star Wares is a well stocked astronomy-related gift shop. Red Belly Black Cafe, winner of Best Tourism Restaurant 2001, offers Canberra's best settings for breakfasts, lunches, and special functions. Visitors can stroll amongst heritage buildings and enjoy stunning panoramic views from the sundial garden and outdoor BBQ area. To assist its astronomy education programs and develop new exhibits, Mt Stromlo maintains a tax-deductible 'Adopt-a-Star' program.

Address: 15 minutes from Canberra City, Mt Stromlo Road, via Cotter Road, Weston Creek, ACT

Hours: Mt Stromlo Observatory Visitors' Centre is open every day (except Christmas) 9:30am-4:30pm.

Cost: Different tour packages, \$6-\$12 adult, \$5-10 concession, \$3.50-\$7 child, \$15-\$25 family.

Contact: Visitors' Centre (02) 6125-0232; Fax (02) 6125-8045

Star Wares Gifts (02) 6125-8903

Red Belly Black Cafe (02) 6287-1518

Email: msovc@mso.anu.edu.au

Web: www.mso.anu.edu.au/msovc

SKYWATCH OBSERVATORY AND ASTRO GOLF

This public observatory is in Coonabarabran, which is also the home of the Siding Spring Observatory. It is located along Timor Rd, 2km west of the clock tower. During the day the large exhibition is open featuring hands on activities, a theatrette, puzzles, computers and a display of pictures and information boards. At night time there is guided telescope viewing. There is also Astro Golf, a popular 18 hole mini golf course. A great family activity, open day and night. Light refreshments are available.

Hours: 2pm to 5pm (closed during the day in February) Night-time hours vary throughout the year as the daylight hours change, so it is always a good idea to call ahead. Bookings not required, but appreciated. Groups welcome but please book. Open every day except Christmas day.

Cost: Adult \$12.10 child/pensioner \$7.15 family \$33.00

Contact: Karl Rafferty (02) 6842-3303 fax: (02) 6842-2978

Email: astro@skywatch.cx

Web: www.skywatch.cx

THE UNIVERSITY OF NSW OBSERVATORY (SYDNEY)

The University opens its observatory to the general public on most Friday nights for viewing sessions. The nights also include regular astronomy talks and a visit to the university's Mini-Planetarium. Bookings are also available for school groups on other nights; group discounts apply. Holiday programs are also organised. For those who are keen, it is possible to join SUNS, the 'Science at UNSW' society. Activities are suitable for all ages. For further information and bookings:

Contact: Outreach Manager (02) 9385-6100

Web: www.scitech.unsw.edu.au Follow links to Outreach Centre

QUEENSLAND

THE GREAT BARRIER REEF OBSERVATORY

Situated on Hamilton Island, the observatory is open to the public during the dry months from April to November. Sessions are held on Tuesday, Thursday and Sunday evenings. Special openings on request. The observatory enjoys dark skies, operates five telescopes, and is staffed by members of the island's astronomical group. Viewing is complimentary.

Contact: (07) 4946-8686

Address: PO Box 40 Hamilton Island Qld 4803

Email: star@whitsunday.net.au

THE SIR THOMAS BRISBANE PLANETARIUM

This world class planetarium is located in the beautiful surrounds of the Mt. Coot-tha Botanic Gardens in Brisbane. Regular programmes are presented, lasting about 45 minutes. The 'Cosmic Skydome' has an artificial sky projected onto the interior surface of a 12.5m dome. The foyer and gallery areas contain an interesting collection of displays and artifacts related to astronomy. The planetarium also has an observatory with a 15cm refractor and a 41cm reflector. Observatory sessions must be pre-booked.

Public shows are 3:30pm & 7:30pm, Wednesday to Friday (also 1:30pm during Qld school holidays). Weekend shows are 1:30pm, 3:30pm and 7:30pm on Saturday and 1:30pm and 3:30pm on Sunday. Visitors are requested to arrive at least 15 minutes before the starting time and bookings are advisable. Not recommended for children under 6. School shows Wed-Fri on a booking basis only.

Skydome \$10 adult, \$6 child (under 15), \$8.50 for concessions, \$28 for a family pass, group rates apply.

Observatory: \$10 adult, \$6 child (under 15)

Bookings: (07) 3403-2578

SPRINGBROOK MOUNTAIN OBSERVATORY

Springbrook National Park is world heritage listed and is only a 45 minute drive from Surfers Paradise. It is a perfect setting for Springbrook Observatory which is open to the general public by appointment, astronomical groups, and researchers. This facility has a C14, C11, 4.5" refractor, and CCD equipment, hydrogen alpha filter for solar prominence observation and sunspot viewing. Next to the observatory is a fully licensed restaurant.

Contact: Andre Clayden (07) 5533-5200, fax (07) 5533-5457

Email: springbrook@iprimus.com.au

Web: www.maguire.com.au/astronomy

OUTBACK QUEENSLAND SKYWATCH

This public observatory is located in Charleville on Cunnamulla Road, near the airport. It is expected by November 2002 it should become the 'Charleville Cosmos Centre'. They have a telescope garden and 'Galactic Theatre'. Booking are essential.

Contact: Visitor Information Centre (07) 4654-3057

Address: PO Box 63, Charleville QLD 4470

Email: murweh@growzone.com.au

SOUTH AUSTRALIA

UNIVERSITY OF SOUTH AUSTRALIA PLANETARIUM

The planetarium was originally installed to teach surveying to students at the university. It is now available to the public. There is a regular show on the 1st Saturday of each month at 3pm. Other sessions are available for groups via bookings.

Address: University of South Australia, Mowson Lakes Campus

Contact: (08) 8302-3138

Web: www.unisa.edu.au/planetarium/

INTERNATIONAL CANGAROO PROJECT, WOOMERA

In 2002 the second 10 metre telescope will be installed at G Range Woomera. The telescopes are used for high energy astrophysical studies of pulsars, supernovae, gamma ray bursts and black holes. It is a joint Japan-Australia university project. Although the telescope is inside the Woomera Security Area, afternoon site visits can be arranged for small groups about a week either side of New Moon, by applying in advance, giving names and addresses. This information is needed to gain access to the range. There is a display in the Woomera Heritage Centre. An idea of the activities, including a picture gallery, is available on the web site. The telescope will be open to visitors at the time of the 2002 solar eclipse. A small charge may be made to cover costs.

Contact: Dr John Patterson (08) 8222-4038 or (08) 8396-1004 (AH)

Fax (08) 8673-7033 mobile 0417 805 547.

Email: jpatters@physics.adelaide.edu.au.

Web: www.physics.adelaide.edu.au/astrophysics/cangaroo.html

TASMANIA

LAUNCESTON PLANETARIUM

The planetarium is in the Queen Victoria Museum, Wellington St.

Show Times: Tuesday to Friday 3:00pm, Saturday 2:00pm and 3:00pm. During government school holidays, shows run Monday to Saturday 2:00pm and 3:00pm. Group bookings by arrangement.

Cost: \$2.20 Children (under 15), \$3.30 adults and \$7.70 family (children under 5 years old are not admitted)

Contact: (03) 6323-3777

Web: www.vision.net.au/~peter/AST/launplan/launplan.htm

PLANETARIUM IN HOBART

This is a lesser known planetarium being tucked away in the centre of Hobart within Dreamworld Antarctic Adventure, located in Salamanca Square. This consists of a modest 5 to 6 metre diameter geodesic dome decked out so that about 15 people can sit inside. There are no age limits. The planetarium projector is a Starlab SL-220 of cylindrical design.

Hours: Open every day (except Christmas Day) from 10am to 5pm. Shows are hourly and run for about 40 minutes.

Contact: 1800 350 028

Web: www.antarctic.com.au

VICTORIA

BALLARAT MUNICIPAL OBSERVATORY

The Observatory contains three historic telescopes: The Jelbart - a 125 mm refractor, the Oddie, a 220 mm Newtonian and the Baker Great Equatorial Telescope - a 650 mm Newtonian, which was commissioned in 1886. In addition, there is a 360 mm Schmidt-Cassegrain, two portable Dobsonians - a 315 mm and a 250 mm. A computer-enhanced, disabled-access 406 Cassegrain is due for commissioning in December 2001. The observatory is open most Friday and some Saturday nights. Daytime tours can also be arranged by appointment.

Contact: (03) 5332-7526

Email: bas@cbl.com.au

Web: www.looksgood.com.au/astronomy.

MELBOURNE OBSERVATORY

The historic Old Melbourne Observatory is located in the Royal Botanic Gardens, Melbourne. On Wednesdays at 2pm an historical presentation is made 'Stars, Cows and Spiderwebs'. There are also Tuesday evening presentations 'The Night Sky Experience'. Bookings are essential for both programs (03) 9252-2429. The Royal Botanic Gardens Melbourne has a visitor centre, function rooms, Observatory Cafe and a Gardens' Shop on the Observatory site.

Bookings: Visitor Centre, Observatory Gate (03) 9252-2300

Web: www.rbgmelb.org.au

MELBOURNE PLANETARIUM

This is Australia's first digital planetarium and is at Scienceworks in Spotswood. The theatre seats 135, and produces shows for all ages including those for amateur astronomers and tertiary students. The planetarium is open 7 days a week from 10am. Bookings are essential.

Contact: (03) 9392-4800

Web: www.museum.vic.gov.au/planetarium

ASTRONOMICAL COURSES, SOURCES OF INFORMATION

The following lists astronomy courses, events, magazines and radio programs known to the authors for 2002. This list is by no means intended to be exhaustive. Across the country there are no doubt many other evening courses held at various universities and colleges. Enquiries from the general public are most welcome. A number of the amateur astronomical societies also provide an invaluable service to public education by their lectures and open nights. You will need to contact the societies for further details. Costs given are subject to change. The Internet also should not be overlooked as a valuable source of information.

IAU 2003

Important international astronomical conference for Sydney

Every three years research astronomers from around the world gather for the General Assembly of the International Astronomical Union. The next GA is to be held in Sydney at the Darling Harbour Convention Centre from 13 to 26 July 2003. This is the first time in thirty years that one has been held in Australia. Although the GA itself is for professional astronomers the organisers plan to use the presence of many overseas astronomers as a focus for public events and activities. Among these is likely to be an astronomy festival with public lectures, debates, an exhibition, solar observing during the day and, with the help of amateur groups, an evening star party.

INTERNATIONAL DARKSKY ASSOCIATION (AUS/NZ)

Contact: Reg R. Wilson FIES (Director, Australian Representative)
+61 (02) 9488-7078 (phone and fax)
32 Carina Road, Turramurra, NSW 2074

Email: regrw@acay.com.au

SYDNEY OUTDOOR LIGHTING IMPROVEMENT SOCIETY

SOLIS is an active group with the aim of bringing the ever increasing sky glow to a standstill.

Address: PO Box 3002, North Turramurra NSW 2074

Contact: Ken Petersen (02) 9634-1736

Email: solislp@netscape.net

Web: sites.netscape.net/solislp/

FUNDING FOR ASTRONOMICAL RESEARCH

The Edward Corbould Research Fund has been established to encourage and assist astronomical research by Australian amateur astronomers and students. Funds are made available annually and disbursed with advice from a research committee appointed with the approval of CSIRO Australia. An amount of \$6,000 has been made available for grants in 2002. Application forms and further information concerning eligibility of applicants and obligations of successful applicants are available from:

The General Secretary, Astronomical Association of Queensland,
PO Box 6101, St. Lucia Qld 4067.

NACAA 2002

The National Australian Convention of Amateur Astronomers is a biennial meeting normally held over Easter. The last convention in 2000 was held in Perth. The 2002 gathering will be in Adelaide, hosted by the Astronomical Society of South Australia. Contact the society (next section) for details.

Web: www.assa.org.au/nacaa2002

SKY AND TELESCOPE MAGAZINE -ASTRONOMY HOTLINE 'SKYLINE'

Telephone 0011-1-617-497-4168. Web: www.skypub.com/

ASTRONOMY MAGAZINE HOMEPAGE

Web: www.kalmbach.com/astro/astronomy.html

GENERAL PUBLICATIONS

ASTROCARDS

The Astronomical Society of NSW runs an information service called 'Astrocards'. This service alerts subscribers to new observable discoveries such as comets, novae, supernovae, bright near-Earth asteroids, or unusual planetary phenomena. The service is available via email or letter and is open to all amateurs.

Cost: \$10 for 10 - subscriptions payable to the ASNSW.

Contact: Greg Bryant (as per 'Comet Tales' below)

SKY & SPACE MAGAZINE

This astronomy and space exploration magazine is produced for Australia and New Zealand. This full-colour magazine is bi-monthly and available through newsagencies or by subscription. Sky & Space also produce a magazine called 'Southern Astronomy'. It is a no frills magazine designed specifically for amateur astronomers. It is available only by subscription.

Contact: (02) 9369-3344, fax (02) 9369-3366.

Address: Sky & Space Publishing, PO Box 1690, Bondi Junction NSW 1355

COMET TALES

This quarterly publication for amateur astronomers covers a variety of topics. It has a strong focus on providing the latest information on comets. Deep-sky and planetary observing, monthly sky highlights, and astronomy news (particularly Australian professional research and amateur star parties) are broadly covered. The publication has expanded significantly since its first issue in 1995.

Cost: \$14 for one year (payable to Greg Bryant, credit card accepted)

Address: 2/100-104 Kissing Point Rd, Dundas NSW 2117

Email: gchbryant@hotmail.com

Web: gchbryant.tripod.com

PERIHELION

A bulletin for comet observers. This newsletter, published by David Seargent, is specifically designed for the Australian observer. It is only for newly discovered comets of 11th magnitude or brighter and visible from Australia. David is an author and contributor to Sky & Space magazine.

Cost: \$12 (for 4 issues per year), \$15 also includes special mail notices for new discoveries (cheques payable to Karagi Publication).

Address: PO Box 204, The Entrance NSW 2261

NEW SOUTH WALES & ACT

ASTROFEST (COONABARABRAN)

This event has been held annually for a number of years. Activities include: observing, lectures, tour of Siding Spring Observatory and Skywatch Observatory, the Bart Bok annual lecture, Science in the Pub (subject to availability) and the Siding Spring Open day (check beforehand to confirm). This jam-packed weekend will be held in November 2002 and is hosted by the Warrumbungle Mountain Motel

Contact: Mark Boyd (02) 6842-1832.

email: warrumbunglelodge@bigpond.com.au

ASTRONOMY COURSES - COONABARABRAN

At the time of publication, it was uncertain whether these courses would be held in 2002 (this is also dependent on the level of interest). They are organised by the Warrumbungle Mountain Motel. See contact details (previous) for Astrofest (Coonabarabran).

VOYAGER PLANETARIUM (SYDNEY)

This is an Astronomy Science Education service. The planetarium visits schools and community groups in the metropolitan area. Programs are available for K to 12. The service also provides astronomical activities for teachers and students. Authorised by the Department of Education.

Contact: Don Whiteman (02) 9642-1574, mobile 0427 642 157

Email: mwtscope@bigpond.com

Web: www.users.bigpond.com/mwtscope

MACQUARIE UNIVERSITY ASTRONOMY OPEN NIGHTS

These nights are specifically designed with the general public in mind. Activities include: a special guest speaker, numerous telescopes operated by local amateurs, and commercial stands with the latest astronomical merchandise. There are two such nights held each year normally in March and October. The venue is Macquarie University (off Epping Rd, North Ryde, Sydney) and commences around 6.30pm. There is a small entrance fee which helps to fund equipment for the university observatory.

MACQUARIE UNIVERSITY FOUNDATION FOR ASTRONOMY

The FFA acts as a support group for astronomy activities at Macquarie University, helping to plan open nights, schools of astronomy and building activities at the university's observatory. Membership subscription is \$20 per year (students \$10). Through its activities the FFA supports community education in astronomy and encourages interested people to participate in astronomical activities.

SOUTH PACIFIC STAR PARTY

An annual national gathering of amateurs for observing under country skies. This is held at the Astronomical Society of NSW's property at Ilford, NSW. This major event now attracts over 400 people from all over Australia and overseas. The 2002 SPSP will be held from 15-17 March. Contact the ASNSW for details (p. 139).

PRACTICAL ASTRONOMY (SASPAC)

A practical astronomy course for beginners and interested amateurs. This is an 8 week course conducted by Sutherland Astronomical Society (SAS) during Spring. Each 1 hour lecture is followed by observations with the society's equipment,

Cost: \$110

Venue: Green Point Observatory (Sutherland, Sydney).

Contact: Chris Toohey phone / fax: (02) 9589-1014

Email: sasi@ozemail.com.au

ASTRONOMY/SPACE EXPLORATION/TELESCOPE TUITION (GOSFORD/CENTRAL COAST)

StarryLady Astronomy Services offer courses in Basic Astronomy and Space Exploration. These will both run in Jan/Feb 2002.

Telescope tuition is available all year by arrangement.

Contact: Lesa Moore (02) 4340-1253

Email: StarryLady@hotmail.com

Web: www.ozemail.com.au/~starrylady

W.E.A. - NEWCASTLE

An entry level astronomy course is run at the Keay Southern Cross Observatory five times per year through the WEA of Newcastle (02) 4926-4066. The course consists of 3 nights of 3 hours and includes sky navigation telescope techniques and historical sky lore.

Astronomical Society of the Hunter members direct and assist.

W.E.A. - SYDNEY OBSERVATORY COURSE

Sydney Observatory and the WEA are likely to run some beginner astronomy courses, based at the observatory, during 2002. Contact WEA (02) 9264-2781 for cost and timetable details.

Web: www.weasydney.com.au

W.E.A. ILLAWARRA PRACTICAL AMATEUR ASTRONOMY COURSE (WOLLONGONG)

Run by the Wollongong Amateur Astronomy Club, this eight week beginners course in amateur astronomy is offered both through the local WEA and by the Astronomy Club. Each class consists of a one hour tutorial followed by viewing through members' telescopes if weather permits. The course program can be found at the W.A.A.C. website.

Web: www.users.bigpond.com/paul.b/index.htm

SKYWORKS PLANETARIUM (SYDNEY)

Skyworks is a travelling educational resource employing the use of a STARLAB Portable Planetarium to visit schools and youth groups.

Authorised by the Department of Education, Skyworks offers astronomical and space related programmes that are curriculum-based to suit years K-12.

Contact: Geoff Zenner (02) 9610-2899, 0427 112 899

fax (02) 9753-1898

Email: sky-works@bigpond.com

Web: www.users.bigpond.com/sky-works

QUESTACON STARLAB (ACT)

Starlab is an inflatable planetarium which can accommodate up to 30 students. The special projector shows the night sky. Questacon have five Starlabs available for hire to schools who have had teachers trained at Questacon's Starlab workshops. Questacon also provides Starlab presentations at schools in Sydney and Melbourne.

Address: Questacon - The National Science & Technology Centre, Canberra ACT 2600

Contact: Geoff Crane (Outreach Ed.) (02) 6270-2820 fax:1800 641 171

Email: gcrane@questacon.edu.au

Web: www.questacon.edu.au

STAR CLASS - ASTRONOMY EDUCATION (ACT)

This part-time home-based business offers a 'Star Kids' astronomy & space club for primary aged children with a monthly newsletter and a members-only website with extra information, puzzles and interactive features like a messageboard. Star Class also provides free regular online astronomy chats, a free email based astronomy discussion forum, and is the Australian National Centre for the Red Rover Goes to Mars project.

Contact: Michael MacDonald & Leonie Cheetham (02) 6253-0970

Address: GPO BOX 271 Canberra ACT 2601

Email: info@starclass.com.au

Web: www.starclass.com.au

NEPEAN COMMUNITY COLLEGE COURSES

Run at the Kings Tableland Observatory in Wentworth Falls (Blue Mountains). See also the entry on page 133.

Contact: (02) 4721-5368 (College)

SYDNEY UNIVERSITY ASTRONOMY COURSES

The University of Sydney Centre for Continuing Education runs regular astronomy courses. Currently there is a sequence of four 10 week courses run in the Autumn and Spring programs over two years.

In 2002 the courses will be 'Modern Astronomy: the Lives of the Stars' (a slightly more detailed look at stellar evolution) and 'Topics in Modern Astronomy' (a series of individual lectures by active astronomers highlighting areas of current research in Australia).

The courses are conducted by Dr John O'Byrne on the main Sydney University campus, but include a viewing night in the Blue Mountains. Look on the web (below) for more details and contact the university's Centre for Continuing Education on (02) 9351-2907 to enroll.

Web: www.physics.usyd.edu.au/~obyrne/cep/cep.html

QUEENSLAND

ASTROFEST

The Queensland Astrofest is held annually at the Lions Camp, Duckadang, about 2 hours drive northwest of Brisbane. It has a dark sky with superb living conditions and a Celestron-14 telescope (the Stewart Observatory). The event is held over six nights. Activities include: presentations from guest professional astronomers, awards in amateur astronomy, swap & sell, barbecue, catered smorgasboard, slide shows and light sports. The event usually attracts over 100 people. The Astrofest is to be held over the week of the 5th to the 11th of August 2002.

Contact: Glenn Lang 0418 169 547

Email: info@aaq.org.au

Web: queenslandastrofest.homestead.com/qldastrofest.html

BRISBANE FIELD NIGHTS

The Brisbane Astronomical Society (BAS) holds a free Public Field Night on the Saturday nearest to the First Quarter Moon, weather permitting at Mt Cootha Lookout, beginning around 6:30 pm. See the society section for contact details for the BAS.

INTRODUCTION TO THE NIGHT SKY COURSE (BUNDABERG)

Run by the Bundy Skywatchers several times a year.

Contact: Karlene Galway (07) 4159-9674

Email: karlene@interworx.com.au

QLD ASTRONOMY EDUCATION CONFERENCE 2003

The next Queensland Astronomy Education Conference will occur in March 2003. The conference aims to promote the teaching of astronomy and its use in a cross curriculum manner in primary and secondary schools. Information about the 1999 Conference can be found at the following web site.

Web: members.optushome.com.au/firstlight/qaec/99_index.htm

STARGAZERS WEEK 2002

O'Reilly's Rainforest Guesthouses will run its annual Stargazers Week from 14th to 18th July. Guests will be treated to spectacular dark skies with telescopic views of winter Milky Way objects, instructional programmes, solar observing and slide shows combined with O'Reillys fine fare and friendly staff.

Contact: Tony Surma (07) 3274 5073.

Web: members.optushome.com.au/firstlight/stargazers/stargazers.htm

SOUTH AUSTRALIA

W.E.A. COURSES (ADELAIDE)

Astronomy courses were run in March, May, July and October in 2001. At the time of publication information was not available for 2002, but similar courses and timings are expected.

Contact: (08) 8223-1272.

Web: www.wea-sa.com.au

TASMANIA

INTRODUCTION TO ASTRONOMY (HOBART)

Beginner astronomy courses are conducted by members of the Astronomical Society of Tasmania at the University of Tasmania's Canopus Hill Optical Observatory Site.

Contact: Greg Burns (03) 6278-2184 (course details & contents)

Web: www.southcom.com.au/~shevillm/ast/

VICTORIA

INTRODUCTION TO ASTRONOMY (MELBOURNE)

This course is designed to introduce you to all aspects of astronomy and to give you a running start in this fascinating field. This is a hands on introduction to the sky, equipment, history, optics, binoculars & telescopes, SETI, the planets, deep sky objects and more. Viewing sessions are included every week (equipment supplied). Held at Chisholm & Holmesglen TAFE Institutes.

Contact: the TAFEs or Chris Ellis (ngc4755@i.net.au)

VASTROC

Victorian Amateur Astronomical Society's Conventions (VASTROC's) are held every second year (alternating years with NACAA Conventions). Activities include keynote speakers, workshops, poster displays, forums, observing, social gatherings at lunch/tea breaks and the convention dinner. The 2001 VASTROC was held by the Astronomical Society of Victoria. The host society for the 2003 VASTROC is yet to be announced.

SKYLINE

A pre-recorded information service, run by the Astronomical Society of Victoria, to cover the latest astronomical discoveries. Cost is only the phone call. (03) 9888-7130. Updated weekly or more often if needed.

THE SPACE SHOW

This Melbourne radio programme is run by Andrew Rennie & Mark Hillyer, Wednesday evening (1 hr) on 3SCB FM (88.3MHz).

C.A.E. COURSES

Beginners and advanced courses are run each semester. Contact the C.A.E. for costs and dates. Phone (03) 9652-0611.

AMATEUR ASTRONOMY SHORTWAVE STATION (VK3 EKH)

The Astronomical Society of Victoria has its own amateur radio callsign, VK3EKH. Using this callsign, Russell Ward has been conducting an amateur radio net for hams and shortwave listeners on the subject of astronomy since August 1989. The net commences each Friday evening at 10pm AEST on 3.543 MHz (LSB). New stations and shortwave listeners are most welcome.

ASTRONOMICAL SOCIETIES

The following is a list of the amateur societies in eastern Australia. A common philosophy within these organisations is the emphasis they place on public education. Enquires from anyone with an interest in astronomy are most welcome. Where given, annual fees are subject to change. The authors of this publication are keen to keep the information in this section 'evergreen'. It would be appreciated if any significant change occurs (especially new organisations) that the society contact Quasar Publishing (p. 2). The deadline for Astronomy 2003 will be July 1, 2002.

Please note that a number of the societies now have Internet homepages. These can be excellent sources of information such as latest astronomical discoveries, society events and connections to other astronomy sites on the Web. Links to the society homepages can be found on the Quasar homepage (www.quasarastronomy.com.au).

NEW SOUTH WALES & ACT

ASTRONOMICAL SOCIETY OF COONABARABRAN

Meets on the third Thursday of each month at 7:30pm at the Coonabarabran High School. The club's 15cm Dobsonian reflector is available for members to hire.

Fees: \$1.00 joining fee plus \$20.00 annual subscription

Address: c/- AAO Private Bag, Coonabarabran NSW 2357

Contact: Paul Cass (02) 6842-2994

Email: cpc@aacbn.aao.gov.au (Paul Cass)

ASTRONOMICAL SOCIETY OF THE HUNTER

Meets at Keay Southern Cross Observatory (near Kurri Kurri) on the 1st Friday of each month at 7:30pm. The Observatory houses a 16" telescope. They also have a club 13.1" portable telescope which is used for school, scouts, service club productions and 'Meet The Astronomers' nights. The observatory at Altair (Mt Olive) is also available. It has an 18" Newtonian with CCD (Phone Technical Officer Ken Charlwood (02) 6577-3220)

Fees: \$20 adult, \$25 family

Address: PO Box 69, Kurri Kurri NSW 2327

Contact: Col Maybury (02) 4937-4664 (ph/fax)

Email: colmay@acay.com.au

ASTRONOMICAL SOCIETY OF NSW

The society holds meetings twice per month at the CSIRO, Division of Radio Physics, Pembroke Rd. (cnr. Vimera Rd), Marsfield. At ordinary meetings, professional astronomers are invited to talk on various astronomical topics. The technical meetings are less formal, where members of the society often present discussions on their amateur projects. Guests are most welcome. The society runs two observing sites. One at Bowen Mountain, near Richmond, west of Sydney, where the ASNSW has an observatory with a 16" telescope. The other is their 50 hectare dark sky property Wiruna, near Ilford. This site includes accommodation buildings, amenities and a 17.5" telescope. A monthly magazine is also published and is included in the membership fee.

Fees: \$43 full, \$10 juniors (under 18) and \$32 student (over 18), \$12 for each additional family member. There is no joining fee.

Address: GPO Box 1123, Sydney, NSW, 2001.

Contact: Max Gardner (02) 9337-3371.

Email: secretary@asnsw.com

Web: www.asnsw.com

THE NEWCASTLE ASTRONOMICAL SOCIETY

Meetings are held on the last Friday of each month (except December), at the University of Newcastle, Lecture Theatre GP, first floor of Linguistics Building at 7:30pm. Most meetings consist of a general summary of what is visible and late breaking news, followed by a variety of short talks on various aspects of astronomy. The club is aimed at the novice astronomer. Observing nights are organised during the year.

Fees: Family \$20, single \$15, student/child \$8, guests \$2

Address: c/- Dept. Physics, Uni. of Newcastle, Callaghan NSW 2308

Contact: Alan Meehan (02) 4929-6600 or

George Barnes (02) 4967-1057

Email: ggbarnes@idl.net.au

www.newcastle.edu.au/departments/ph/plasma/NAS/nas_home

CANBERRA ASTRONOMICAL SOCIETY

CAS meetings are held on the 3rd Thursday of every month (except July and December) starting at 8:00pm at the Duffield Building, Mt Stromlo. Meetings regularly feature guest speakers from both the amateur and professional community who give a short presentation on astronomical topics.

Members of all ages, experience and interests are welcomed and the society has a broad range of programs to support the beginner through to the very experienced amateur astronomer including introductory and deep sky nights. Membership includes the CAS monthly newsletter 'Southern Cross'.

Fees: \$30 adult, \$15 student & \$40 family, half rates Jan to Jun

Address: PO Box 1338, Woden ACT 2606

Contact: John Howard (02) 6248-0552

Email: cas@enzerink.net

Web: www.mso.anu.edu.au/cas/

BRITISH ASTRONOMICAL ASSOCIATION - NSW BRANCH

The BAA meets at Sydney Observatory on the third Wednesday of each month, commencing at 7:30pm. At these meetings, professional astronomers are often invited as guest speakers. Regular practical workshops are also held on weekends. The BAA also publish a regular newsletter called The Astronomer's Bulletin.

Address: Sydney Observatory, Watson Rd, The Rocks, Sydney 2000

Fees: \$35 full, \$17.50 junior/concession and there are family concessions for \$52.50. There is a joining fee.

Contact: Elizabeth Cocking (02) 9398-9705

SHOALHAVEN ASTRONOMERS

Meet at the library, Falls Creek Public School on the third Friday of each month at 7:30pm. The first Friday of each month is a viewing night. They also have a quarterly journal and monthly astroflyers.

Fees: \$25 full membership.

Address: PO Box 1053, Nowra NSW 2541

Contact: Jack Apfelbaum (president) (02) 4423-2255

Web: www.shoal.net.au/~astronomy/index.html

HAWKESBURY ASTRONOMICAL ASSOCIATION

Meetings are held once a month on the 2nd Wednesday, commencing 7:45pm, in the Tebbutt Rooms at the Windsor Library, Dight St. Windsor. They also observe on Third Quarter and New Moon weekends. The club organises several public field nights per year and presents a basic introduction to astronomy. The HAA prides itself on being family orientated and aims to cater for the newcomer at a basic level.

Fees: \$20 adult, \$30 family and \$10 junior.

Address: PO Box 670, Windsor NSW 2756

Contact: Adrian Saw (02) 4572-1568

Email: haa@rpi.net.au

Web: www.rpi.net.au/~haa

ILLAWARRA ASTRONOMICAL SOCIETY

Meetings are held at the Wollongong Science Centre and Planetarium, Fairy Meadow, on the second Tuesday of each month at 8:00pm. There are regular observing nights held at various sites near Wollongong.

Address: PO Box 1814, Wollongong NSW 2500

Contact: Dave Wheeler (02) 4226-3584

Email: smr@cse.unsw.edu.au (Steve Russell)

Web: members.optusnet.com.au/~smr

MACARTHUR ASTRONOMICAL SOCIETY

The MAS holds meetings, with guest speakers and workshops, every 3rd Monday of the month at 7.30pm at the University of Western Sydney - Macarthur, Building 22, Room 5. The society also publishes a monthly journal, Prime Focus. They hold monthly Star Nights for public education at the Rotary Observatory UWS. There is also dark sky observing for members within 40 minutes travel from Campbelltown. The MAS encourages and supports members from novice to expert. They provide Full, Student, Pensioner and Family levels of membership.

Address: c/- Secretary, PO Box 17, Minto NSW 2566

Contact: Ian Cook (02) 4627-1424

Email: skyview@zipworld.com.au

NORTHERN SYDNEY ASTRONOMICAL SOCIETY INC

Meetings are held at the Sports Pavilion, St. Ignatius College, Lane Cove on the 3rd Tuesday of each month at 7:30pm. The society has a quarterly journal, Reflections. Monthly observing nights are held at North Turramurra golf course.

Fees: \$40 adult, \$20 student/pensioner and \$60 family

Address: PO Box 3002, North Turramurra NSW 2074

Contact: Ron Washington (President) (02) 9949-3544

Email: nsas@easy.com.au

Web: www.easy.com.au/nsas

PORT MACQUARIE ASTRONOMICAL ASSOCIATION INC.

Meets at the Port Macquarie Observatory (in Rotary Park, opposite Town Beach) on the last Monday of each month at 6.30pm.

Address: Port Macquarie Astronomical Association Inc
P. O. Box 1453, Port Macquarie NSW 2444

Contact: Jim Daniel (02) 6583-1933

Email: jaidan1@bigpond.com.au

SUTHERLAND ASTRONOMICAL SOCIETY

The Society operates from Green Point Observatory near Sutherland. The observatory houses a 41cm reflecting telescope and 35cm C14 SCT and has a well equipped library and meeting hall. Other telescopes include a high quality 15cm refractor and 20cm Newtonian. The SAS meets every Thursday at 8:00pm (visitors welcome). The society also publishes a regular newsletter and star nights are available for interested groups. There is also a public open night and astronomy course held annually.

Fees: \$40 full, \$30 student/associate, \$15 junior/pensioners and \$50 for families plus joining fee - full/family \$25, others \$10

Address: PO Box 31, Sutherland NSW 1499

Contact: Secretary (02) 9589-1014 (phone/fax)

Email: sasi@ozemail.com.au

Web: www.ozemail.com.au/~sasi

WESTERN SYDNEY AMATEUR ASTRONOMY GROUP INC

The society meets 3rd Wednesday of the month at the Nepean Astronomy Centre, University of Western Sydney, Werrington Campus. There are also regular observing nights at the Beames Observatory at Linden and a bi-monthly newsletter.

Fees: \$30 full, \$22 student/concession, \$40 family/school groups and \$10 for newsletter only.

Address: PO Box 400, Kingswood NSW 2747

Contact: Peter Nakitch (02) 9835-1824 (pnakitch@tig.com.au)

Brett White (Pres.) (02) 9623-2496 (brett@nepean.net.au)

Club message bank: (02) 8250-6250.

Web: www.nepean.uws.edu.au/astronomy/observatory/wsaag.htm

WOLLONGONG AMATEUR ASTRONOMY CLUB

Holds monthly meetings on the first Thursday of each month, commencing 7:30pm, at the Unanderra Community Centre, Princess Highway, Unanderra. Visitors are welcome to attend. New Moon and Last Quarter observing nights are held at either Cataract Scout Park or on private land near Robertson in the Southern Highlands. Please contact us by phone or email for details. A monthly newsletter, Wollongong Observer, is produced. Membership is \$10 per year.

Address: PO Box 398, Unanderra NSW 2526

Contact: Andrew Wood (02) 4272-4505

Email: bandawood@bigpond.com

Web: www.users.bigpond.com/paul.b/index.htm

UNIVERSITY OF NEW ENGLAND AND NORTHERN TABLELANDS ASTRONOMICAL SOCIETY (UNENTAS)

Meetings are held once per month (except December and January) at 6:30pm AEST on Thursday evenings at the Kirby Observatory. The society has access to the UNE Physics Department astronomy and observing facilities, and aims to cater for members at all levels. Meetings usually include a talk on some astronomical subject, and viewing, with a short time for any business.

Fees: Donation to tea/coffee fund.

Address: Dr Margaret Sharpe, 33A Brown St, Armidale 2350, or UNE internal mail to M. C. Sharpe, LCL, UNE.

Contact: (02) 6771-1123 (ph/fax), mobile 0428 711 123

Email: msharpe@metz.une.edu.au

TAREE ASTRONOMICAL SOCIETY

(Information may be out of date) The society meets at the Taree High School on the second Thursday of each month at 7:00pm.

Address: c/- PO Box 90 Tuncurry NSW 2428

Contact: Richard Mozejko (president)

Email: rmozejk@tpgi.com.au

QUEENSLAND

ASTRONOMICAL ASSOCIATION OF QUEENSLAND (AAQ)

Meetings are held on the afternoon of the second Saturday of the month at 2.30pm in the lecture theatre of the Sir Thomas Brisbane Planetarium, Mt Coot-tha Botanic Gardens. The club's observing nights are held two weeks later. They also hold regular astrocamps, public field nights and publish a monthly journal and Annual Proceedings.

Fees: \$35 adult, \$50 family, \$23 student and pensioner.

Address: PO Box 6101, St. Lucia, Qld, 4067

Contact: Bill Oliver (07) 3391-4587

Email: info@aaq.org.au

Web: www.aaq.org.au/

TROPICAL STARGAZERS

(Formerly Astronomy 20 South) This Hamilton Island based group meets on the fourth Wednesday of each month and holds regular viewing sessions. Members also staff the island observatory on a voluntary basis.

Address: PO Box 40 Hamilton Island Qld 4803

Contact: Ray Johnston (07) 4946-8686

Email: star@whitsunday.net.au

BUNDABERG ASTRONOMICAL SOCIETY

Meetings are held at Alloway Observatory on every Friday at 7:30pm. The first Friday of the month are general meetings and are not held in January. The society also publishes a bi-monthly paper. Regular field nights are held as required.

Fees: \$30 adult, \$15 junior and \$20 country, no joining fee required

Address: PO Box 4221 South Bundaberg Qld 4670

Contact: Bill Fielding, Don Gray or Peter Rehbein (07) 4159-7232 (answering service)

email: iluka@widebay.net.au (Peter Rehbein)

Web: www.angelfire.com/al/AstronDirectory

BUNDY SKYWATCHERS (BUNDABERG)

Meets every Friday with three nights a month being field nights.

Fees: Currently only \$5.00 per year.

Address: 534 Moorlands Road, Bundaberg Qld 4670

Contact: Karlene Galway (07) 4159-9674

Email: karlene@interworx.com.au

BRISBANE ASTRONOMICAL SOCIETY

Meets on the second Friday of each month at 7:30pm at Kelvin Grove State High School Library. There is a bi-monthly newsletter. The society holds regular field nights for members and the public, as well as astrocamps. They also conduct observing nights for the public on the Saturday nearest First Quarter Moon each month, at the Mt. Coot-tha Lookout, starting at 6.30pm. Everyone is welcome to attend. The society also has a comprehensive lending library, and there are telescopes available for loan to members.

Fees: \$25 adult, \$30 family, \$15 student/pensioner, \$22 country member, \$27 family country members, also a \$5 joining fee.

Address: PO Box 204, Morningside Qld 4170

Contact: David Durham (07) 3321-8511 (recorded club information service)

Email: nwilliams@acenet.net.au

Web: www.ozemail.com.au/~nwilliam/bas/bas.html

CAIRNS ASTRONOMY GROUP

Hold monthly meetings from June to November at Bob's place, 18 Yurongi St, Caravonica Qld 4878

Contact: Bob Dollery (07) 4058-1180

CENTRAL QUEENSLAND ASTRONOMY CLUB

(information may be out-of-date) This group is based in Rockhampton. They meet on the New Moon Friday of each month and now have a dark sky site for observing.

Contact: Ron Inslay (07) 4926-2156

MT. ISA ASTRONOMY GROUP

(Information may be out of date) The society meets at their dark sky observing site at the Lions Youth Camp on Lake Moondarra (17km outside of Mount Isa). Meetings are held monthly, usually near the New Moon. They have an observatory at this location. Public star parties are held annually.

Fees: \$35 per year

Address: PO Box 1556, Mount Isa Qld 4825

REDLANDS ASTRONOMICAL SOCIETY

This is the newest astronomical society in the Brisbane area. They meet at Ormiston College, Ormiston (27km SE of Brisbane) twice a month on the 2nd and last Tuesdays. The second meeting is for skywatching.

Address: PO Box 2048, Wellington Point Qld 4160

Contact: Ross Spence (President) (07) 3822-5545

Email: r.a.l.spence@uq.net.au

SOUTH EAST QUEENSLAND ASTRONOMICAL SOCIETY

The Society meets on the third Monday of the month at Kedron High School, from February to November. Meetings commence at 7.30pm and visitors are welcome. The SEQAS have a quarterly newsletter Universal Times and a library. Telescopes and star atlases are available to members, including assistance for those who wish to construct their own telescopes. An Urban Observers Group conducts a field night at Indooroopilly High School, on the first Sunday of each month; the public are welcome. Visits to dark sky locations and residential weekends are organised monthly.

Fees: \$20 for adults, \$25 for family members, and concession \$10. No joining fees are applicable.

Address: PO Box 60, Everton Park Qld 4053

Contacts: Graham Long (07) 3205-4541 David Larkin (07) 3844-7904

Email: mcerlean@powerup.com.au

Website: www.powerup.com.au/~mcerlean

SOUTHERN ASTRONOMICAL SOCIETY

Monthly meetings are held at Ormeau State School on Saturdays, commencing at 7:00pm (the date varies depending on the phase of the Moon). Meetings normally finish at 9pm so that members and guests can observe through telescopes. The society holds monthly astrocamps at a dark sky location. It also produces a bi-monthly newsletter.

Fees: \$28 adult and \$21 student, discount for additional family members

Address: PO Box 867, Beenleigh Qld 4207

Contact: Kevin Dixon (07) 5537-3852

Email: Renato Langersek (President) renato@odyssey.com.au

Web: www.sas.org.au

SUN COAST ASTRONOMICAL SOCIETY

Meetings are held on the third Friday of each month at 7pm. The venue is the Beerwah Field Study Centre, Roys Road, Beerwah. There is a bi-monthly newsletter.

Address: PO Box 961, Caloundra Qld 4551

Contact: Terry O'Keefe (07) 5491-5257 or Glen Lang (07) 5496-0310

email: tokeefe@austarnet.com.au

Web: suncoastastronomy.homestead.com/new.html

TOWNSVILLE ASTRONOMY GROUP

Observe on the first Saturday closest to New Moon at Alligator Creek (20km south of Townsville) or at Kelso Dam. There is a quarterly newsletter.

Address: 21 Gladys St, Kelso Qld 4815

Contact: Richard Free (07) 4789-2214

email: mgib@tpg.com.au (Murray Gibson)

SOUTH AUSTRALIA

ASTRONOMICAL SOCIETY OF SOUTH AUSTRALIA

Meetings are held on the 1st Wednesday of each month (except January) at the University of Adelaide, North Terrace Campus. The society maintains three observatories. The Heights Observatory at Heights School, Modbury, houses a 0.3m telescope. The society's northern country site is Stockport Observatory, located at Stockport,

80km north of Adelaide. Stockport has 0.4m, 0.45m and 0.5m telescopes. The southern observing site houses a 0.4m telescope, and is located at Douglas Scrub, McLaren Flat. Public education is important to the ASSA with various lectures and observing nights. The society publishes a monthly newsletter. Public field nights are held monthly at the Heights Observatory, and at Douglas Scrub. The Stockport Observatory hosts a Star Party each quarter. The Whyalla Branch of the ASSA holds monthly meetings and regular viewing nights. Contact John Murray (area co-ordinator) (08) 8645-2829.

Address: GPO Box 199, Adelaide SA 5001

Contact: (08) 8338-1231

Email: info@assa.org.au

Web: www.assa.org.au/

TASMANIA

ASTRONOMICAL SOCIETY OF TASMANIA (AST)

Meetings are held at the Hutchins School, Sandy Bay, on the last Tuesday of each month except December. The September meeting is held at Launceston Planetarium. The AST run two public nights in Hobart per year (at the Canopus Hill Observatory) and two in Launceston (at the Launceston Planetarium), usually in April and November. Presentations are made to school and community groups. The society offers viewing at Canopus Hill using the University of Tasmania's 16" telescope and the society's telescopes

Fees: \$40 Family, \$35 Full Adult Member, Town & Country and \$20 Junior (up to age 18 years.)

Address: Secretary, Mr. Laurie Priest, PO Box 1654, Hobart Tas 7001

Contact: (03) 6244-3476

Northern Tas. Launceston - Karenne Barnes (03) 6344-7100

Northwest Tas. Devonport - Peter Sayers (03) 6424-2588

Email: shevillm@southcom.com.au (Shevill Mathers, President)

Web: www.southcom.com.au/~shevillm/ast/

VICTORIA

ASTRONOMICAL SOCIETY OF VICTORIA (ASV)

The ASV aims to cater for the needs of both beginners and experienced amateur astronomers. Visitors are welcome at the society's general meetings, held at 8pm on the 2nd Wednesday of each month, except January, at the National Herbarium, Birdwood Ave, South Yarra. Meetings feature speakers on topics of interest to amateur astronomers. ASV specialist sections hold regular meetings to cater for members' interests in a wide range of astronomy topics. The society holds courses regularly for beginners in astronomy and in telescope making. ASV members meet socially most Friday nights at the society's premises in suburban Burwood to observe through the 0.5m Le Marquand telescope. The Society's Leon Mow Dark Sky Site near Heathcote is used for regular observing, the popular annual Star Party and Star-Be-Cue events. Members can use the society's portable 0.7m aperture telescope and facilities for overnight visits at this site. Further membership advantages include: the society's bi-monthly newsletter Crux, the Yearbook, email news, members' nights at Melbourne Observatory, daytime astronomy meetings, the Skyline telephone information service, loan telescopes, an extensive library and computer facilities.

Fees: Metropolitan \$42 (family \$47); junior (under 19) \$26; country / interstate \$26 (family \$32); seniors \$26 (family \$32). A joining fee of \$20 applies to all categories except Juniors.

Address: GPO Box 1059J, Melbourne, Vic 3001

Contact: Linda Mockridge (Public Relations Officer) (03) 9888-7130

E-mail: mockrdge@alphalink.com.au

Web: www.asv.org.au

THE ASTRONOMICAL SOCIETY OF EAST GIPPSLAND

This is a small group which operates in Bairnsdale and the surrounding districts. Meetings and dark sky observations are held at 10 Waterholes Rd, Bairnsdale Vic 3875.

Contact: Mike Finn (03) 5156-0676

Email: mikef1@hotmail.net.au

Web: pending

ASTRONOMICAL SOCIETY OF MELBOURNE

The ASM has grown to over 90 members in the last three years, and has a team of enthusiastic amateurs whose goal is to put enjoyment and camaraderie into their astronomy. The team has regular club nights and also a dark sky site for viewing. The ASM has a highly active ATM (Amateur Telescope Making) team, which has produced over twenty instruments in the last three years, including high performance refractors from 3" to 5", and reflectors from 6" to one currently under construction at 29". The ASM also have a new dark sky site, for serious deep sky viewing, located south of Lang Lang (close to Melbourne). The society's library has also now over 500 titles available for members to borrow. The ASM specialises in catering for beginners (includes an experienced astronomy teacher), as well as providing the technical knowledge sought by the experienced amateur.

Address: PO Box 92, Bentleigh, Vic 3204

Contact: Chris Ellis 0412 318 125 (recorded info line (03) 9517-9250)

Email: ngc4755@i.net.au

Web: www.astromelb.i.net.au

BALLARAT ASTRONOMICAL SOCIETY

The Society was founded in 1958 and since then has been the custodian of the Ballarat Municipal Observatory, which was established in 1886. For details of available telescopes see under Ballarat Municipal Observatory. The Society holds a general meeting on the second Friday of each month and various activities are available on the other Friday evenings. Membership is open to anyone over the age of 10 years. The BAS publishes a quarterly Bulletin and holds regular public viewing nights.

Fees: \$30 full, \$50 family, \$20 associate, junior and pensioner, \$10 subscriber (joining fee \$5 junior, \$10 associate).

Address: PO Box 284, Ballarat Vic. 3353.

Contact: (03) 5332-7526 (society information)

Email: bas@cbl.com.au

Web: www.looksgood.com.au/astronomy

ASTRONOMICAL SOCIETY OF ALBURY WODONGA

The society meets regularly on the first Wednesday of each month (except January) at Victory Primary School, Drages Road, Wodonga at 8pm. Viewing nights are arranged at various locations including the Wodonga High School Observatory. There is also a continuing program of grazing occultation observations.

Address: 1 Poplar St, Wodonga Vic 3690

Contact: John Hills (02) 6024-7255, fax (02) 6024-4540

Email: jhills@tpgi.com.au

Web: www.asaw.tripod.com

ASTRONOMICAL SOCIETY OF GEELONG

Meets every Friday from about 8:30 pm, with a business meeting on the last Friday of each month. The venue is the ASG Club Room, Geelong Showgrounds, Breakwater Road, Geelong. The society holds regular viewing nights for schools and community groups as required.

Fees: \$50 adult, \$25 junior/concession.

Address: PO Box 1799, Geelong Vic 3220

Contact: Frank Baker (secretary) 0407 345 070

Email: Robert Cowdell Rob.Cowdell@nre.vic.gov.au

LATROBE VALLEY ASTRONOMICAL SOCIETY

The society meets each month (except December and January). Nebulous News, the society's bi-monthly newsletter, is also published. The LVAS is active in astronomy education, viewing nights in Gippsland and is developing a new hill top observatory near the township of Tyers.

Fees: \$25 adult, \$13 associate (members living more than 50km from Morwell)

Address: PO Box 80, Glengarry Vic 3854

Contact: Rob Read (03) 5176-1560 fax (03) 5176-1571

Email: lvas@raja.computers.com.au

OASIS STARGAZERS CLUB MILDURA INC

Oasis conduct regular viewing nights which are open to the public and once a month have a public activity night. Oasis also make themselves available for community and school groups for viewing nights.

Address: PO Box 378CP, Mildura Vic 3500

Contact: Kerry Needs (03) 5021-1330 (kerryynn@mvctrus.org.au)
David Martin (03) 5023-3931, 0409 500 377 (dmartin12@vtown.com.au)

Web: pending

ASTRONOMICAL SOCIETY OF FRANKSTON (ASF)

Meetings are held on the 3rd Wednesday of each month (except December) at 8pm, at The Peninsula School, Wooralla Drive, Mt. Eliza. Visitors are always welcome. The ASF have: a choice of multiple concurrent sessions at each monthly meeting, a bimonthly newsletter, an email newsgroup for rapidly alerting members of late breaking information, a library of books, videos, CD ROMs, telescopes, binoculars and computers all available for members to borrow, specialist sections providing guidance in a wide range of active astronomical interests, regular social events, co-ordinating and engaging in active field observing expeditions in concert with other similar organisations (both amateur and professional), and regular viewing nights at the society's dark sky Briars property on the Mornington Peninsula. An observatory is well under construction at this site. All age groups and levels of experience are represented within the ASF. Regular monthly public viewing nights are held on the first Friday of each month at 8pm at the Briars site, Mt. Martha. The ASF is renowned for its 'Astronomy on the Move' viewing nights and presentations which have educated schools, the public and community groups in the south east Victoria region since 1969. The ASF also co-ordinates and runs the southern Australian aurora telephone alert service for members of any astronomical society that wish to improve their chances of observing this phenomenon.

Fees: \$35 adult, \$30 concession, \$25 student, \$45 family, \$40 family concession, \$16 newsletter only, \$50 international.

Address: PO Box 596, Frankston Vic 3199

Contact: Peter Skilton (mobile) 0419 253 252

Email: aggro@peninsula.starway.net.au (Peter Lowe)

Web: www.asfnet.20m.com

THE BENDIGO DISTRICT ASTRONOMICAL SOCIETY

The society meets at the BRiT (3rd Floor of McCrae St Campus) at 7:30pm on the 4th Wednesday of each month (excluding December). A monthly newsletter is published and regular field nights are held around Bendigo.

Fees: \$28 adult, \$15 concession and \$40 family.

Address: PO Box 123, Golden Square, Bendigo Vic 3555

Contact: Neil Linton (03) 5448-8352

Web: www.bendigo.net.au/~rbath/index.htm

NORTHERN TERRITORY

ALICE SPRINGS ASTRONOMICAL SOCIETY

The society holds meetings on the 2nd Monday of each month at the Motor Registry Office, METEL Centre. Two star viewing nights are held each month, at their dark sky site 6 km east of Alice Springs, on Saturdays closest to New Moon.

Address: Box 739, Alice Springs NT 0871

Contact: Secretary Annette Green (08) 8952-9817

Email: sugarsm@bigpond.com.au

Web: www.ozemail.com.au/~kkramer/astalice.html

DARWIN ASTRONOMY GROUP

Monthly viewing nights are held during the dry season plus special astronomical events. Astronomy nights can be organised for schools, clubs as well as amateur telescope making.

Contact: Phillip Smith (08) 8945-9450

Email: hapchap@bigpond.com

Web: www.ozemail.com.au/~hapchap

GLOSSARY

AEST Australian Eastern Standard Time.

ACST Australian Central Standard Time.

Albedo The ratio of light reflected from a Solar System object to that received by it. (A complete reflection gives an albedo of 1.0 or 100%).

Algol A variable star of a class known as eclipsing variables. Algol's brightness fluctuates every 69 hours as it is eclipsed by its invisible companion.

Almanac A set of tables giving positions of Sun, Moon & planets at various times, plus other astronomical information; an *Ephemeris*.

Altazimuth co-ordinates The angular height (*altitude*) of an object above or below the horizon and its angular direction (*azimuth*) from north measured towards the east.

Altitude The angular elevation of an object above or below the horizon.

Angular diameter The apparent diameter of an object measured in degrees or radians.

Angular separation The angular distance between two celestial bodies measured in degrees.

Aphelion The point in an orbit of a comet, planet or minor planet most distant from the Sun. It is the opposite to *perihelion*.

Apogee The point at which a body in orbit around the Earth reaches its farthest distance from the Earth. It is the opposite to *perigee*.

Asterism A recognisable grouping of visible stars. The stars may belong to one or more constellations. The grouping will have a name, for example 'The Teapot' in Sagittarius.

Asteroid See *Minor Planet*.

Astronomical unit The average distance from Earth to the Sun, approximately 149.6 million km, which equals 1 AU.

Azimuth Horizontal co-ordinate of an object's position in the sky. Derived by drawing an imaginary vertical line from the object to the horizon below. The position is then expressed in degrees east from the north point.

Celestial equator A projection of the Earth's equator onto the *celestial sphere*.

Celestial poles Points on the *celestial sphere* directly above the Earth's poles about which all the stars seem to rotate; known as the north and south celestial poles (NCP and SCP).

Celestial sphere Imaginary sphere of infinite size surrounding the Earth and to which celestial bodies seem to be attached.

Circumpolar stars Stars which never set. To determine which stars are circumpolar from a particular place, subtract the observer's latitude from 90°. This provides the minimum *declination* a star must have to be considered circumpolar.

Colour index The difference in the magnitudes of an object measured at two different wavelengths. It is a measure of the colour (temperature) of a star.

Coma The head of a *comet*, usually the brightest part.

Comet Small icy body that orbits the Sun and produces tails of gas and dust when approaching the Sun.

Conjunction An alignment of two bodies; their least *angular separation* as seen from Earth. When a *superior planet* is said to be in conjunction it is with the Sun (unless stated otherwise).

Conjunction - Inferior When the Earth, an *inferior planet* (Mercury or Venus) and the Sun are in a line in that order.

Conjunction - Superior When the Earth and an *inferior planet* (Mercury or Venus) are situated on opposite sides of the Sun.

Constellation A pattern of stars identified by name, usually of mythological gods, people, animals, or objects.

Cosmology The study of the large-scale structure and evolution of the whole Universe.

Culmination The instant when a celestial body crosses the *meridian*; an object culminates when it reaches its highest point above the observers horizon.

Declination (Dec) One part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of a body north (+) or south (-) of the *celestial equator* and is similar to lines of latitude on the Earth.

Diurnal motion The daily motion of the sky produced by rotation of the Earth, causing the rising and setting of the Sun, Moon, planets and stars.

Eccentricity A measure of how 'long or thin' an ellipse is. If the eccentricity equals zero, you have a circle.

Eclipse When one object passes into the shadow of another.

Eclipse of the Moon When the Moon passes into the shadow cone of the Earth. It is a total eclipse when the Moon is immersed in the umbral shadow, partial if only partly covered by the *umbra*, and penumbral if the Moon passes only through the *penumbra* of the Earth's shadow.

Eclipse of the Sun When the Moon passes in front of the Sun. Total when the Moon has a larger *angular diameter* than the Sun and completely covers the disc, annular if smaller (leaving a ring of sunlight surrounding the Moon), and partial if only partly covered.

Ecliptic The plane of the Earth's orbit projected onto the *celestial sphere*. It can also be defined as the Sun's path against the stars.

Ellipse An oval. The shape of the orbit of the planets. The axes of an ellipse are called the minor axis and major axis.

Elongation The *angular separation* of two bodies. The greatest elongation of Mercury and Venus occur when the planets are at their most *angular distance* from the Sun, as viewed from the Earth.

Emission nebula A cloud of glowing gas excited by ultraviolet radiation from hot stars.

Ephemeris (plural ephemerides) A tabulated list of positions for an object calculated from its orbital elements.

Epoch A date chosen as a reference point for observations. This book uses Epoch 2000.0 for all co-ordinate data and is compatible with modern star atlases.

Equation of Time The difference between apparent and mean solar time.

Equinox The two times of the year when the Sun crosses the *celestial equator*; vernal or spring equinox occurs about March 21st, and autumnal or fall equinox about September 22nd (northern hemisphere seasons).

Galactic equator The great circle along the line of the Milky Way, marking the central plane of our *galaxy*.

Galaxy A large disk or ball of billions of stars and *nebulae*. They are the largest individual structures in the Universe.

Galilean satellites Named after their discoverer, Galileo Galilei. The four brightest satellites of Jupiter: Io, Europa, Ganymede, and Callisto, (also known as the Jovian satellites).

Geocentric As viewed or measured from the centre of the Earth.

Gibbous Phase of a planet or the Moon more than fifty percent illuminated. For example, the Moon is gibbous between first and last quarter.

Globular Cluster A huge sphere containing thousands of stars. They surround our *galaxy* and other nearby galaxies.

Heliocentric As viewed or measured from the centre of the Sun.

Hour Angle The angular measure of the distance of an object from the local *meridian*.

Inclination The angle that the plane of the orbit of one astronomical body makes with the plane of the orbit of another. Usually the reference is the *ecliptic*.

Inferior planet A planet orbiting the Sun inside Earth's orbit. That is Mercury and Venus.

Julian date The number of days since noon on 1st January 4713 B.C. It is useful for astronomical observations as it saves confusion with other calendars. The starting date chosen was arbitrary but far enough back in time for there to be no astronomical records prior to then.

Large Magellanic Cloud (LMC) Satellite *galaxy* to our own Milky Way system, appearing to the unaided eye as a large nebulous patch situated in the *constellation* of Dorado. From mid-southern latitudes the LMC is *circumpolar*.

Light year The distance that light traverses in a vacuum during one year (approximately 9,460,529,700,000 km).

Lunation The period of time between two consecutive New Moons.

Magnitude Brightness scale of stellar objects. From one magnitude to the next the ratio of brightness is the 5th root of 100, or approximately 2.52. The lower the number the brighter the star. The brightest stars as seen from Earth are magnitude -1 (except for the Sun which is -26). The faintest visible to the unaided are 6 (in dark skies).

Magnitude - absolute The apparent magnitude a star would have if it were placed at a distance of 10 *parsecs* (32.6 *light years*).

Meridian The local meridian is an imaginary line running directly overhead from north to south. The *right ascension* on the meridian equals local *sidereal* time.

Meteor (also Shooting or Falling Star) A small particle striking the Earth's atmosphere that is heated to incandescence by friction with air molecules.

Meteor shower A group of *meteors* that appear to originate from a small region of the sky (the radiant).

Meteor swarm (or stream) *Meteoroids* grouped in a localised region of an orbit around the Sun (the source of *meteor showers*).

Meteorite A *meteor* that survives its trip through the atmosphere and reaches the ground.

Meteoroid A small solid particle moving in orbit about the Sun.

Minor planet Small rocky objects which revolve around the Sun. Most lie between the orbits of Mars and Jupiter in the asteroid belt.

Minute of arc An angular measure (each degree is divided in 60 minutes of arc).

Mira A variable star in the *constellation* of Cetus, with a range in brightness from 2nd to 10th *magnitude*, and a mean period of 331 days. Known as Mira the Wonderful, it is the brightest and most famous of the long period pulsating variables.

Nadir The point on the *celestial sphere* directly opposite the *zenith*.

Nebula A cloud of interstellar gas and dust. See also *emission*, *reflection* and *planetary nebula*.

Node One of two points at which an orbit passes through a reference plane (usually the *ecliptic*).

Oblateness The ratio of a planet's polar to its equatorial diameter.

Obliquity The degree of inclination (or tilt) of a planet's equator to its orbital plane.

Occultation The disappearance of one celestial body behind another.

Omega Centauri A globular star cluster in the *constellation* of Centaurus. Globulars are made up of tens of thousands of stars and form a shell around our galaxy. Omega Centauri and 47 Tucanae are two of the finest examples of these objects.

Open star cluster A loose association of stars numbering from a few dozen to hundreds.

Opposition When a celestial body is opposite the Sun in the sky.

Orbit The path followed by one body as it moves around another.

Parallax An apparent shift in the positions of nearby stars (relative to more distant ones) from the changing position of the Earth in its orbit around the Sun. The size of the shift can be used to measure the distances to the nearer stars.

Parsec A unit of distance used by astronomers which is equal to 3.26 *light years*. A parsec is defined as the distance to a celestial body whose *parallax* is one arc second.

Penumbra Area of partial illumination in the shadow of a planet surrounding the *Umbra*. Also zone of intermediate brightness between a sunspot and the solar photosphere.

Perigee The point at which a body in orbit around the Earth most closely approaches the Earth.

Perihelion The point in an orbit closest to the Sun, of a comet, planet or minor planet. It is opposite to *aphelion*.

Perturbation Small changes in the motion of a body caused by the gravitational effects of another body.

Planetary nebula An expanding shell of gas ejected from a star. Thought to be the outer layers of a red giant during its latter stages of evolution, the core of which becomes a white dwarf.

Planisphere A handheld aid used to identify which constellations are visible to an observer on any particular date and time.

Polar axis The axis around which a celestial body rotates.

Proper motion The small change in position of nearby stars due to motion across the line of sight (measured in seconds of arc per year).

Quadrature A configuration that two celestial bodies have apparent longitudes that differ by 90° as viewed from a third body.

Reflection nebula. A gas cloud illuminated by a nearby star.

Retrograde motion 1. An actual motion contrary to the general direction of the bodies in the Solar System. An example of actual retrograde motion is Neptune's satellite Triton.
2. Apparent retrograde motion is the westward motion of a planet with respect to the stars which occurs near opposition (outer planets) or near inferior conjunction (inner planets).

Right ascension (R.A.) Part of the equatorial co-ordinate system used to specify the location of an object in the sky. It is the angular distance of an object from an imaginary line in the sky. It is similar to lines of longitude on the Earth but is measured in hours (24hrs = 360°).

Second of arc An angular measure. Each degree contains 3600 seconds of arc, and each *minute of arc* contains 60 seconds.

Sidereal time A method of keeping time which uses the motion of the stars rather than the Sun. One sidereal day is equal to 23hrs56m4s of normal solar time.

Small Magellanic Cloud (SMC) Satellite *galaxy* to our own Milky Way system, appearing to the unaided eye as a nebulous patch in the constellation of Tucana. From mid-southern latitudes the SMC is *circumpolar*.

Solstice The time when the Sun is farthest from the *celestial equator*. In the southern hemisphere around June 21st marks the shortest day of the year, and around December 21st marks the longest day.

Spectral type A star's spectral classification determined by its *spectrum*.

Spectrum The light of an object spread out like a rainbow. As well as this continuous spectrum, a star normally shows a distinctive set of dark and light lines which are characteristic of its composition.

Superior planet A planet orbiting the Sun outside Earth's orbit.

Synodic period The period of a planet's orbit with respect to the Earth.

Transit The passage of Mercury or Venus in front of the Sun's disc or the passage of a satellite or its shadow across the face of its planet.

Transit the meridian or meridian passage The passage of a heavenly body across the *meridian*.

Twilight The short period of time before sunrise and after sunset during which there is not complete darkness.

Twilight - astronomical Astronomical twilight ends (in the evening sky) or begins (in the morning sky) when the Sun is 18° below the horizon.

Twilight - civil Civil twilight ends or begins when the Sun is 6° below the horizon.

Twilight - nautical Nautical twilight ends or begins when the Sun is 12° below the horizon.

Umbra Zone of maximum darkness in the shadow of a planet. Also the darkest part of a sunspot.

Universal time A time system measured on the Meridian of Greenwich, it is 10 hours less than Australian Eastern Standard Time (*AEST*).

Zenith The point directly overhead (90° in altitude).

Zenith Hourly Rate A general guide to the expected intensity of any given meteor shower. It is a theoretical rate, assuming a radiant at the *zenith* with a sky limiting magnitude of 6.5.

Zodiac The traditional twelve constellations that lie across the *ecliptic* (astrologers ignore Ophiuchus, which is very much a part of the Zodiac).

GREEK ALPHABET							
A, α	Alpha	Z, ζ	Zeta	Λ, λ	Lambda	Π, π	Pi
B, β	Beta	H, η	Eta	M, μ	Mu	Ρ, ρ	Rho
Γ, γ	Gamma	Θ, θ, ϑ	Theta	N, ν	Nu	Σ, σ	Sigma
Δ, δ	Delta	I, ι	Iota	Ξ, ξ	Xi	T, τ	Tau
E, ε	Epsilon	K, κ	Kappa	O, ο	Omicron	Υ, υ	Upsilon
						Φ, φ	Phi
						Χ, χ	Chi
						Ψ, ψ	Psi
						Ω, ω	Omega

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ESTIMATING ANGLES IN THE SKY. When held 0.5m(20 inches) from the eye, each division on this scale corresponds to 1 of arc.

0° 1° 2° 3° 4° 5° 6° 7° 8° 9° 10° 15° 20° 25°

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